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PORTO RICO AGRICULTURAL EXPERIMENT STATION
MAYAGUEZ, PORTO RICO
Under the supervision of the
UNITED STATES DEPARTMENT OF AGRICULTURE

REPORT OF THE PORTO RICO AGRICULTURAL EXPERIMENT STATION

1930

Issued December, 1931

UNITED STATES DEPARTMENT OF AGRICULTURE
OFFICE OF EXPERIMENT STATIONS

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PORTO RICO AGRICULTURAL EXPERIMENT STATION, MAYAGUEZ

[Under the supervision of the Office of Experiment Stations, United States Department of Agriculture]

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[1] Appointment effective Oct. 1, 1930.

PORTO RICO AGRICULTURAL EXPERIMENT STATION
MAYAGUEZ, P. R.

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REPORT OF THE PORTO RICO AGRICULTURAL EXPERIMENT STATION, 1930

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REPORT OF THE DIRECTOR

T. B. McClelland

During the year covered by this report several important changes were made in the station staff. D. W. May, director of the station since 1904, retired in April, 1930. He was succeeded by G. F. Freeman, who died suddenly in September, 1930. C. M. Tucker resigned his position as plant pathologist to accept a position with the Florida Agricultural Experiment Station. The station staff, already depleted, was further reduced by these changes. The need for additional staff members is urgent.

Publications during the year included the results of an intensive survey of all the local representative citrus plantations (*7*),[1] and of investigations on coffee insects, coffee culture, colorability of grapefruit, and pineapple culture,[2] and an analytical index of publications of the station (*8*). A timely article on the Java-Barbados sugarcane hybrids in Porto Rico was submitted for publication in an agricultural journal (*5*).

[1] Italic numbers in parentheses refer to Literature Cited, p. 50.
[2] Mimeographed numbers of Agricultural Notes, available copies of which may be had upon application to the director of the station.

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Sugarcane breeding was much more extensively carried on than ever before. Several of the seedlings under test for several years, notably Mayaguez Nos. 3, 7, and 42, are very promising, being resistant to mosaic, and high in sucrose and in tonnage. Approximately 15,500 cuttings of Mayaguez seedlings were distributed among several hundred farmers and to all the centrals on the island. From several thousand cuttings of P. O. J. 2878, distributed to local cane growers beginning in 1928, several thousand acres of the variety are being grown for the harvest in 1932. This rapid extension was made possible by the adoption of the Mayaguez single-eye method of planting to accelerate propagation. Considerable cane work was carried on by the station in cooperation with the various local centrals.

The breeding of both field and sweet corn was continued.

Work with citrus included studies of root development, looking toward improved cultural and fertilizer practices, and to determining the best method of controlling time of blooming. Analyses were made of leaves in connection with the fertilizer studies.

Applying smoke to pineapple plants was tried as a means of inducing blossoming.

At various fruit growers' meetings the station was represented for the purpose of maintaining and increasing an interest in cooperation.

Seed of Excelsa coffee was extensively distributed. This variety is especially promising for planting in many localities. The need for fertilizing coffee was demonstrated after the hurricane by differences in ability to recuperate as shown by trees which had received different fertilizer treatments.

Experiments were made with beans, sweetpotatoes, dasheens, and taros.

Both economic and ornamental plants were extensively distributed.

In the chemical division, studies were made of the decomposition of cane straw in the soil, cane-sirup manufacture, and the effect on the soil of different fertilizer treatments continued through many years.

Cattle breeding and management were continued along lines formerly followed. In a general survey of parasites affecting domestic animals, studies were made of the stomach worm, the hookworm, and the lungworm of cattle, and the common tapeworm of cattle and goats.

PRACTICAL RESULTS OF THE WORK OF THE STATION

The retirement of D. W. May from the directorship concludes a definite cycle in the history of the station. Under his able leadership the station exerted a profound effect on the agriculture of the island. This seems a fitting time to enumerate some of the many ways in which the station, with Mr. May as director, has greatly benefited the people of Porto Rico.

The station erected the first silo in Porto Rico in 1908. Many silos are now to be found throughout the island. The station built the first local dipping tank for cattle. Over 50 dipping tanks modeled after that one are now in use in various parts of the island, and numerous benefits have resulted from their use.

The station introduced and distributed Napier or elephant grass (*Pennisetum purpureum*) (fig. 1) and Guatemala grass (*Tripsacum laxum*) (fig. 2), each of which produces nearly twice as much forage

FIGURE 1.—Napier or elephant grass, 10 months' growth

FIGURE 2.—Guatemala grass

as does either guinea grass (*Panicum maximum*) or Para grass (*P. barbinode*). Elephant and Guatemala grasses are mainstays of the local dairy industry. Were it not for these grasses the local milk supply would be much smaller than it is to-day. In 1912 the station introduced molasses grass (*Melinis minutiflora*) (fig. 3), which, in the report for that year, was pronounced "the most productive grass tried here so far on lowland." The station also introduced and distributed Java grass (*Polytrias praemorsa*) (fig. 3), which is said to be the best grass for grazing animals in Java. It is also a beautiful lawn grass.[2]

The station has been engaged for 25 years in importing cattle of improved breeds and has loaned animals for free service. This has been a large factor in improving the local cattle.

The station reported for the first time the presence in Porto Rico of over 80 species of internal and external parasites of domestic ani-

FIGURE 3.—Java lawn grass in the foreground; molasses grass in the background

mals, including poultry. Some of the parasites are of interest only to scientists, but many have an important bearing on the local live-stock industry. The station worked out the life history of the swine kidney worm (*Stephanurus dentatus*), found the intermediate host of the liver fluke of cattle and goats in Porto Rico, and determined methods for control of the latter. As a result, one central has reduced its annual losses in one district from an average of 20 work bulls to 1 or 2. The station worked out control measures for stomach and nodular worms in cattle under Porto Rican conditions, and found a successful treatment for one type of tick fever (piroplasmosis). Systematic examinations of the carcasses of 100 cattle, 100 goats, and 200 swine have been made at the local abattoir to determine the species of parasites, the percentage infested, and the importance of the parasites collected. The station now has a record

[2] The station is indebted to the Office of Foreign Plant Introduction of the United States Department of Agriculture for many of the useful plants which it has introduced into Porto Rico.

of over 900 examinations of fecal matter, blood, and skin scrapings of animals from various parts of the island, indicating the species, the degree of infection, and the distribution of various parasitic infestations.

In July, 1908, the station imported five nuclei of Italian bees, from which the local honey industry has largely developed.

Ten years ago the station introduced giant toads (*Bufo marinus*) from Barbados and subsequently distributed them to all parts of the island in lots varying from 10 to 1,000. They may now be seen at night in great numbers in the fields. Examinations of the stomachs disclosed the presence of changas, white grubs, ants, cockroaches, and numerous other harmful insects. These toads are thus performing an important service in insect control. In 1929 the station introduced a dozen frogs, or "mountain chickens" (*Leptodactylus pentadactylus*) from Dominica. It is hoped that they will eventually prove an important source of food.

The station introduced, tested, and distributed *Crotalaria striata* and *Tephrosia candida*, the two principal cover crops now planted in local citrus groves.

In 1909 the station introduced vanilla (*Vanilla planifolia*) for commercial development. Vanilla growing was found to be profitable, and cuttings of the vine were distributed. On a single plantation one crop grown from cuttings distributed by the station brought on the market over $13,000.

The station has shown by experiment how carbonate of lime injuriously affects the mineral nutrition of rice and pineapples, and has determined the cause of chlorosis in pineapple plants. As a result of these studies the station has been able to advise planters concerning the selection of suitable lands for pineapple growing. Many of the planters have profited by following this advice.

Since 1917 the station has maintained in San Juan an office which is devoted solely to the interests of local fruit growers. Through it they have received continuous help in solving their various problems.

The station has introduced, tested, and distributed many valuable root crops. The Key West variety of sweetpotato has been found to be the most productive of the many varieties introduced. Widely distributed by the station, this variety is now grown in all parts of the island, and has yielded over 15 tons of tubers per acre. Shortly after its establishment the station introduced dasheens from Trinidad and elsewhere. At present the dasheen forms an important source of the local food supply. The station introduced and distributed the Penang taro, a very superior table variety, pronouncedly different in this respect from any of the taros grown locally. Its culture in Porto Rico has been highly successful.

The station has introduced and bred for distribution many kinds of plants of ornamental value. Among the most striking of these perhaps is the amaranth purple variety of Bougainvillea, commonly referred to as the red or the crimson variety. It is now growing throughout the island. The station has also developed many new varieties of hibiscus, which are to be seen growing in different parts of Porto Rico.

The station has introduced many miscellaneous kinds of trees and plants of promise for Porto Rico, and is said to have the best grown,

the best identified, and the most representative arboretum in tropical America.

The station discovered that *Phytophthora palmivora* is the causal organism of the coconut bud rot disease, and has recommended measures for combating it. Heavy losses in avocado trees in certain localities were shown to be due to a strain of Phytophthora closely resembling *P. cinnamomi*. As a result of this finding the station is able to advise prospective growers where to plant or not to plant their avocado trees.

For years the station has been conducting fertilizer experiments with coffee and has shown that under suitable fertilization coffee yields can be increased profitably. Potash is the element that largely affects yield. When this element is deficient, coffee yields decrease. The station has also experimented in coffee pruning and in coffee shading, and has introduced and tested for distribution many varieties of coffee, including Excelsa coffee, which is of outstanding merit.

The mosaic disease has been found to be the limiting factor in sugarcane growing in certain districts of Porto Rico. In 1919 the station introduced cuttings of the variety Uba Natal, or Japanese cane, which is immune to the disease. The attitude of local sugar growers in respect to this introduction was clearly shown in a memorial they presented to the station "in testimony of gratitude," stating that the introduction saved the local industry from destruction. Uba cane has thus played a very important rôle in the economic history of the island. (Fig. 4.) The variety undoubtedly will be grown for forage after it has been supplanted by superior cane varieties for sugar. Other introductions immune to mosaic included P. O. J. 2725, in June, 1923, and P. O. J. 2878, in March, 1927. P. O. J. 2725 is grown extensively by several of the local sugar centrals and is considered to be one of the more important varieties for Porto Rico. The station introduced P. O. J. 2878 directly from Java. It now occupies several thousand acres of land in Porto Rico. The station also introduced S. C. 12/4 which now grows on thousands of acres and in some districts to the exclusion of any other cane variety. Among the varieties immune or highly resistant to mosaic that have been bred at the station are Mayaguez Nos. 3, 7, 28, 42, and 49. Some of these are expected to occupy a prominent place in the future of Porto Rican cane growing.

IN RETROSPECT

By D. W. May[4]

When the writer came to the station 26 years ago, agriculture on the island was in a low state of development. Coffee, a leading product, was low in price. The continuous cropping of the soil for many years had resulted in a decided depletion of its fertility and a consequent poor yield of coffee. Sugar was decreasing in yield because of the failure to practice systems of rotation and to employ improved methods of cultivation. The varieties Otaheite and Cristalina were continuously grown on the same soil. The fruit industry

[4] Director of the station from 1904 to 1930.

was represented by the shipment of some wild oranges, mainly from Mayaguez. Agricultural labor was poorly paid, 50 cents a day being the wage given an able-bodied man for his work. Improved agricultural machinery was lacking, and the wooden plow and the plantation pick hoe were much in evidence. Cattle had been bred indiscriminately without any definite object in view.

FIGURE 4.—Uba cane; fifth ratoons yielding over 15 tons per acre

Horses were small and wanting in strength for field work. Pigs were of the razorback type, and the game breed of chickens was kept mainly for cock fighting.

The agricultural experiment station was the only agency then in Porto Rico in a position to attack the problems confronting the planters. The function of the station was to make a systematic

study of all problems related to agriculture, and to interpret the results and practices to the people of the island.

The condition of the farm selected for the station was typical of the farms throughout the island. Fences were missing, the lowlands needed draining, the highlands were gullied, timber had been cut from the land for charcoal making, and the old sugar mill, to be occupied by offices and laboratories, was unroofed.

After becoming established, the station found it necessary to devote its energies to problems of agriculture and production, including the introduction of improved varieties of economic plants and purebred livestock, the improvement of those already on the island, and the dissemination of timely agricultural information. This was a rather wide and varied program to be covered by the appropriation allotted to the station.

The introduction of improved varieties of plants of economic value seemed to offer the greatest possible good for the least expenditure of money. Seed of Arabian types of coffee which were bringing the highest prices in the States was imported from Java. Eventually these coffees were found to be attacked by the same kind of diseases and insects that troubled the type of Arabian coffee grown for years in Porto Rico. Grown under local conditions, most of the coffees approximated the flavor and aroma of the Porto Rico coffee and fitted into the same trade. Certain types of the Liberian group of coffees were later introduced by the station. Some of them were found to be more vigorous than the Arabian types, to give larger yields, and to resist leaf-miner attacks. The station has worked assiduously for the past 25 years to induce coffee planters to diversify their crops where possible, to use some rational plan of fertilizing the coffee on the different soil types for the most profitable yield of coffee, and to further the industry by cooperating for the sale of their produce in the best market possible.

In 1904 the station made its first introduction of sugarcane, including the varieties Yellow Caledonia, White Bamboo, Demerara Nos. 74, 95, and 117, Trinidad 77, and Tiboo Merd, which is similar to Cristalina. Later introductions were made annually, and the station shortly began breeding new varieties which were exchanged with other countries carrying on similar lines of work. The new canes were carefully propagated, and when found to be of outstanding merit, free from disease, and resistant to insect attack, were distributed in small lots to local planters. Some of the varieties proved to be better adapted to certain soils than others.

Desirable varieties were rapidly propagated and sold for seed purposes by the planters, who were very much alive to the merits of these canes. The rapid changes brought about by the substitution of improved for old varieties as the former appeared in the station plats were due to the skill and perseverance of representative planters in various parts of the island. When the mosaic disease was devastating local cane fields the station distributed over the infected areas an immune variety (Uba) that saved the local industry. The planters grew this variety and sold all the cuttings at eight months' growth for planting purposes, thus rapidly extending the area planted to the variety. It tillers very profusely, producing sometimes 80 stalks to the hill, a fact that greatly favors its rapid increase. The total immunity of the variety led to its incorporation in the breeding work

of the station. The percentage of immunity in the progeny has not been fully determined, but its capacity in this regard is remarkable.

No single factor is doing more for the sugar industry than the improvement of varieties by breeding. Not only are higher producing canes being developed, but also some varieties that are so resistant to disease as to result, in some instances, in the virtual salvation of the industry. Another important point in cane culture is the study of the soil. The station has made many experiments in fertilizing cane, but the soils in the different parts of the island vary to such an extent as to make of doubtful value any wide application of results. Each planter should determine for himself the relative values of each method of soil testing and the amount and kind of fertilizers his area needs for maximum profitable production.

From its beginning 26 years ago, fruit growing has become one of the leading industries of the island, the shipments now having a value of several million dollars annually. In this expansion the station may claim a creditable part. Fruit growing, although still largely in the experimental stage, is not only adding to the wealth of the planter, but is also giving employment to laborers for a greater part of the year than ever before. Local planters now foster the growth of the wild orange on the coffee plantations in order to increase their annual income. Budded orange and grapefruit trees are being planted and some of the lesser known fruits are being tested as a source of possible added income.

During the 26 years under review the livestock of the island has shown steady improvement. The station has imported horses, cattle, goats, pigs, and poultry for its own use and for farmers in various parts of the island. The horse has never been employed to any extent as a draft animal in Porto Rico. The first importations were probably small animals. Their descendants lack size and strength for heavy work. They are giving way to the automobile on the highway. Horses are bred for saddle use on the plantation and are used as beasts of burden on the mountain trails. A change in economic conditions may again increase their use. Cattle for centuries have locally been used as draft animals. They have maintained a vigorous and muscular frame, but are low producers of milk and late in maturing. However, they are here and are the foundation stock upon which to build a better race.

In improving the cattle the farmer should select a breed that carries the desired characteristics for crossing. In Porto Rico a dairy breed is needed above all else. Other factors which should receive consideration are early maturity, improved conformation, ability to work, and adaptability to a climate that is warm throughout the year. The Guernsey breed more nearly meets these requirements than does any other breed. The Guernsey is somewhat similar to the native cattle in form and color, and the resulting crosses are more symmetrical and show fewer undesirable characteristics as to form than do crosses between Porto Rican cattle and other breeds. The registered Guernseys on the island outnumber the registered cattle of any other breed.

The pig is used to consume the waste products of the home. There are few other sources of waste available for pigs. Under present conditions pork can be imported much more cheaply than it can be produced locally.

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One of the greatest needs in Porto Rico is improved poultry. The drawbacks to poultry raising can be overcome. The greatest handicap to successful poultry raising is the lack of home-grown feed. The greatest pests are the rat, the mongoose, and human thieves, and the worst diseases are chicken pox and roup. Conditions are sufficiently favorable to enable Porto Rico to export rather than import poultry and poultry products.

The station has distributed tons of seed of the nonsaccharine sorghums and finds that the varieties grow well in most parts of the island. They are recommended especially as a feed for poultry and should supplant some of the grains imported for dairy cattle. The nonsaccharine sorghums are especially productive in the dry regions in summer.

The appropriations for the station have been small and for the most part made by the Congress of the United States. The insular government made a few special appropriations in the early years of the station. Later it has been the policy of the insular government to maintain its own station rather than to increase and strengthen the work of the Federal station. Of late years the Federal station has had not only to finance its steadily increasing experimental work, but also to provide buildings and equipment for it. This has made it necessary to practice the most severe economy. Buildings have been erected by farm labor during such slack periods as the dry season. Certain local building materials have been used in preference to the more expensive imported materials, and valuable information has been collected relative to the availability and economy of the former in a country in which the natural resources have been greatly depleted.

The hurricane of September, 1928, badly damaged many station buildings. Special appropriations were made for repairs. Roofs of various buildings were repaired; laborers' cottages, a greenhouse, and warehouses were repaired or rebuilt; a modern sanitary milking shed and feed shed and feed room replaced the antiquated ones, and two wings were added to the main building. This reconstruction left the station better and more permanently equipped with buildings than before the hurricane.

REPORT OF THE ASSISTANT CHEMIST

By J. O. Carrero

MANAGEMENT OF CANE SOILS

Preliminary work to determine the most convenient method of disposing of cane tops and trash, and the effects of the methods tested on the soil organic matter and nitrogen were previously outlined (*3; 4*). These studies were pursued by following the fluctuations of the carbon dioxide and the nitrate nitrogen produced at certain intervals under laboratory-controlled conditions. Results were obtained on one soil and on two methods of trash disposal, (1) leaving the trash as mulch, and (2) mixing the trash with soil. Observations were also made on the effect of the addition of lime, phosphate, potash, and nitrogen. However, it was felt that neither of these two methods of trash disposal was completely satisfactory, because the

former, which is the more commonly practiced, is the slower in transforming the organic matter, even if there are other points in its favor; and the second method can not be actually practiced in the field because plowing is done there only every third or fifth year. Under such conditions trash would not be thoroughly incorporated with the soil, but rather would be buried in layers. Observations on plowing showed that the trash was buried in horizontal, inclined, or vertical layers generally at depths of 5 to 8 inches, and that the layers were 8 to 12 inches apart. This suggested testing the method of placing the trash in the drainage ditches of the previous year, making new ditches, and covering the trash with part of the soil taken from the new ditches, even when plowing was not practiced. This method seemed to have special points in its favor. To determine the value of these points, laboratory experiments under controlled conditions were made, since a field was not available for use.

Experiments during the year were made with soil alone, soil with trash as mulch, trash mixed with soil, trash placed 1, 2, and 3 inches, respectively, below the surface in a horizontal layer, and trash placed in an inclined layer reaching from bottom to top of the vessel containing the soil. The experiments were made on two different kinds of soil, a dark brown and a reddish clay, in both limed and unlimed condition, the amount of lime used being sufficient to neutralize the soil. The lime was applied in three ways, (1) left on top of the soil, (2) mixed thoroughly with the soil, and (3) spread on the surface of the trash layer. Sufficient water was added to maintain the optimum moisture content of the soil. The first analyses were made 15 days after the experiment was started, and thereafter every tenth day. The glass containers used were weighed weekly and were made up to weight by the addition of rain water.

Observations showed that the water penetrated with great difficulty when the trash was placed in horizontal layers below the surface. In nearly all instances where the trash was 1, 2, or 3 inches below the surface and sufficient water to bring the soil to an optimum moisture content had been added, the water penetrated as far as the trash layer, at which point penetration was arrested even though the water stood one-fourth to one-half inch above the soil surface. For the water to penetrate below the trash layer required several hours, and in most instances a glass rod had to be plunged vertically through the soil to help the water to penetrate. No such difficulty was experienced when the trash layer was left as a mulch, mixed with the soil, or placed in vertical or inclined position. The weekly weighings afforded information on the rate of water evaporation. These weighings were compared with those of soil not receiving trash. The loss of moisture varied slightly from week to week. However, a good correlation was observed between soils receiving no treatment and those receiving trash, except for the soil receiving it as mulch. Very little difference was observed in the weekly moisture losses between soil alone and samples receiving trash either mixed thoroughly with the soil or placed below the surface, or in vertical or inclined position. Soils with straw as mulch, however, lost only one-fourth to one-half as much moisture as did the other samples. Both soils lost equally throughout the experiment.

No attempt was made to determine the quantity of carbon dioxide produced. Only the nitrate-nitrogen content of the soil was deter-

mined. The two soils differed greatly in nitrate content. The unlimed dark type had 70 parts per million and the limed soil from 78 to 80 parts per million, whereas the unlimed reddish type had from 3 to 4 parts per million and the limed soil from 8 to 10 parts per million. These soils showed small steady increases every time they were analyzed. Again, unlimed soils with which the trash was thoroughly mixed contained no nitrate and limed dark soil less than 1 part per million, whereas nitrates were totally lacking in the light-colored soil, whether limed or not.

There was a drop in the nitrate content of soils receiving trash as mulch, whether limed or not, as compared with the soils receiving no treatment, the loss increasing up to the fifth analysis. Soils to which trash had been added in horizontal layers contained nitrates, but the drop in content was greater than that shown by the mulched samples. The losses in the soils receiving trash in vertical or inclined layers were smaller than when the trash was applied in horizontal layers, and the loss tended to increase up to the fifth analysis.

For some unknown reason in the sixth analysis the changes in nitrate content in most instances were four to five times as great as those in the fifth analysis, whereas in the other instances the soils that analyzed 3 to 4 parts per million in the fifth analysis showed 130 parts of nitrate nitrogen per million in the sixth analysis. Rain water, collected from the roof of a glass house and stored in a wooden tank, had been used in the experiments without any trouble up to this time. Apparently the water used in the fifth weighing had become contaminated, for although the increase in nitrates made the results worthless after the fifth analysis, these increases remained constant until the end of the experiment.

A large number of nitrate-nitrogen determinations were necessary in the study of the cane-trash decomposition. These determinations were made by means of the colorimetric phenol-disulphonic acid method. Often considerable difficulty was experienced in examining the soil extracts, especially those of some of the dark soils and in instances in which the trash added had undergone decomposition. To obviate this difficulty several methods of extraction were tried, and that of Emerson (*6*) was finally adopted. It is based on extraction with water containing 0.625 gram of copper sulphate. This is made alkaline with calcium oxide and magnesium carbonate previous to filtration. Untreated soils yielded colorless extracts which gave practically colorless residues, or residues with a faint tint, whereas soils receiving treatments usually yielded extracts with a barely perceptible color which became more pronounced on concentration, and finally yielded yellowish to light-grayish residues. Extraction of these residues with filtration and evaporation again yielded colored residues. These residues on treatment with phenol-disulphonic acid yielded darker solutions. The dark color interfered greatly in the comparison with the clear-colored standard solution.

The difficulty was caused by the presence of a small amount of soluble organic matter which was not precipitated by the copper and calcium hydroxides formed, or by the magnesium carbonate. Two methods were tried for the destruction of this organic material, (1) the addition of a small amount of potassium permanganate to the filtered extract previous to evaporation, and (2) the addition of hydrogen peroxide to the extract previous to evaporation, or to

the dry residue. The first method affected the organic matter in solution, but just what its action was could not be easily determined from the color of the extract or that of the residue, because the reduced manganese oxide imparted its color to the solution. On the other hand, the residue when dissolved in phenol-disulphonic acid, later made alkaline with ammonium hydrate, yielded on several occasions a yellow solution with a light-brown tint as the result of the presence of some manganese in the solution.

Trials with hydrogen peroxide yielded white residues regardless of whether the hydrogen peroxide was added during or after evaporation and irrespective of the darkness of the extract. The colorless residue when dissolved in phenol-disulphonic acid yielded a solution with no dark or brown tinge. Consequently, no trouble was experienced in the comparison with the standard solution. However, in the first tests, 2.5, 5, 10, and 15 cubic centimeters of a 3 per cent solution were used, as is recommended by the Pharmacopoeia of the United States (*11, p. 216*). The colorimeter readings were expected to be lower than for those of the untreated samples, since no dark or brown color interfered, but the readings decreased with increases in the amount of peroxide used, even when the lowest amount of peroxide used yielded a white residue with no trace of organic matter.

Apparently hydrogen peroxide or some of the preservative used in the United States standard product acted on the nitrates. Tests made to prove this point, in which the standard potassium nitrate solution was used for comparison, showed decreased readings with increases in the amounts of peroxide used. To avoid any possible loss by free acid, different amounts of a calcium hydroxide solution were used, but failed to stop the loss. Tests showed that the smallest amount of hydrogen peroxide sufficient to destroy the organic matter varied between 1 and 2.5 cubic centimeters of the standard 3 per cent solution.

A number of determinations were made comparing untreated extracts and those to which peroxide to the extent of 1, 1.5, 2, and 2.5 cubic centimeters had been added. In most instances 1, 1.5, and 2 cubic centimeters of peroxide did not affect the colorimetric reading, but when more than 2.5 cubic centimeters was added, and especially 5 cubic centimeters, the loss in nitrates was noticeable. However, further studies with the smallest possible additions showed that 1, 1.5, and 2 cubic centimeters when added before evaporation of the extract was started always yielded white residues which gave an uncolored solution when treated with phenol-disulphonic acid, and showed no loss in nitrate when compared with untreated solutions.

Further study is needed before the proposed modification of the treatment of the soil extract is adopted. If the nitrates are not affected by the use of small amounts of peroxide, the accurate and more rapid colorimetric nitrate method may be used instead of the slower reduction method when colored soil extracts are analyzed.

CANE-SIRUP MANUFACTURE

Work on cane-sirup manufacture was continued whenever cane juice was available for the purpose. Trials included the manufacture of sirup directly from cane juice without treatment; treatment

of the juice with lime, with and without the addition of phosphate; and treatment of the juice with lime, with and without the addition of phosphate, but with the addition of citric acid or tartaric acid to restore the juice to its original acidity. The final products were compared in clarity, color, flavor, and tendency to crystallize after being allowed to stand.

The use of lime alone or lime and phosphates always improved the clarity of the sirup, but the color was darker than that of sirup from untreated juice. Addition of citric or tartaric acids to defecated juice brought further improvement in clarity, color, and tendency to crystal formation in the sirup. Apparently the addition of acid produces the inversion of sucrose because crystals did not form when the product stood. The product obtained by the use of citric and tartaric acid was a clear, light-colored sirup, agreeably flavored, and of slightly acid taste. Tartaric acid has an advantage over citric acid since tartrates of lime and potassium are of slight solubility and crystallize out, leaving a reduced acidity, whereas the citrates of these salts are soluble.

The experiments were made on a small laboratory scale only, and should be made on a large scale.

REPORT OF THE HORTICULTURIST

By T. B. McClelland

COFFEE

In the 1929 report it was mentioned that the hurricane damage to the station plantings of Excelsa coffee was comparatively slight, and that the crop following the 1928 hurricane was more than half normal (*9*). The crop of the present season (1930) surpassed any previously produced by this variety. A group of 12 unpruned trees 14 years old produced 379.1 liters of cherries, which is an average production of 31.6 liters per tree, and is equivalent to slightly more than 6 pounds of marketable coffee. A group of 37 trees, topped at 12 feet, produced 565.9 liters of cherries, averaging 15.3 liters or about 3 pounds of marketable coffee per tree. These yields served to increase the high esteem in which Excelsa coffee was already held. During the year approximately 418,000 seeds of this variety were distributed. Since only 300 Excelsa trees are required to plant an acre, because of the large size which this species attains, this distribution was sufficient to plant over 1,000 acres of land and at the same time allow for selection and for discarding individuals proving in the nursery to be inferior. Because of vigorous growth, high production, adaptability to sun exposure, and resistance to the leaf miner, this species is strongly recommended for planting in locations not suited to the Arabian coffee because of soil depletion, sun exposure, or leaf-miner damage.

In addition to the Excelsa coffee, 132,000 seeds of different varieties of Arabian coffee were distributed, bringing the total distribution to 550,000 coffee seeds.

About 30,000 seeds of *Gliricidia sepium* were distributed for trial plantings of shade for coffee. At the station this tree grows vigorously wherever it is planted. Its roots are abundantly supplied

with nodules of nitrogen-fixing bacteria. The growth has been slow and meager in some other localities at higher elevations although the soil was inoculated. Until the requirements are better understood only trial plantings should be made in the different localities. Easy propagation, rapid growth, desirable size and shape are in its favor as a coffee shade tree, whereas susceptibility to *Corticium koleroga* and attacks of a borer belonging to the genus Xyleutes, both of which affect coffee, and susceptibility to certain scale insects not observed on coffee, are against its use.

Experiments with fertilizers for coffee progressed satisfactorily. The south field plats of Arabian coffee produced practically nothing in the year following the hurricane. The subsequent recovery of the well-fertilized plats, particularly of those receiving potash in the fertilizer mixture, was notable, and many are now carrying an excellent crop. The striking variation in recovery showed that trees already in poor condition, because of failure to treat them with a suitable fertilizer, possessed much less recuperative force than did the trees which were in vigorous condition before the hurricane.

At Las Vegas all the plats which received complete fertilizer considerably surpassed the check in yield, their average production being more than two and one-half times that of the check.

In the nursery the seedlings which are to be planted on plats for testing the nitrogen-potash ratio have grown well and are ready for transplanting when weather conditions are favorable. The drainage in these plats, formerly very poor, has been greatly improved by deepening the ditches and is now considered to be satisfactory.

The twelfth crop from the plats of Bourbon coffee, as in all previous crops, showed a heavier production following the application of ammonium sulphate in complete fertilizer than where sodium nitrate was the nitrogen carrier. The trees in this planting were spaced 8 feet apart each way, and because of their luxuriant development are now crowding to such an extent as to necessitate ending the fertilizer trials. The planting will be used to test the effect on production caused by removing alternate trees, and will be divided into two parts of equal area, one containing twice as many trees as the other.

As the result of the work with fertilizers, timely recommendations for the use of a fertilizer mixture proportionately high in potash were brought to the attention of the planters through (1) a lecture given at Los Cafeteros, Mayaguez, in November, with about 50 persons in attendance; (2) the publication of a mimeographed number of Agricultural Notes in September, 1930,[5] and (3) numerous personal interviews and inspections in the field. A general interest in this matter has been aroused and is increasing. As a result of the station work one planter is now fertilizing 100 acres of land, and others are fertilizing less extensive areas.

COCONUTS

A final report on the coconut-fertilizer work of the station to date was submitted for publication (*10*). The report shows existence of wide differences in production between individual palms of the

[5] Available copies may be had upon application to the director of the station.

same age, receiving the same cultural and fertilizer treatment, and grown under apparently very uniform soil conditions. Such differences could be ascribed only to inherent differences in the palms themselves, and indicate that the line giving the greatest promise of improvement in coconut production is that of breeding and planting from selected palms only.

AVOCADOS AND MANGOES

Avocado growing in the more moist regions of the island is extremely hazardous because of the presence there of the Phytophthora root disease. Grafts have been made of leading Guatemalan varieties with the purpose of planting them in a drier region than that in which the station is located.

As was done in former years, extensive distributions were made of seedlings of the Chinese mango, Cambodiana, and of other mango varieties.

BEANS

Two crops of selections from bean crosses were grown, and one variety test was made in continuation of work previously reported (*9, p. 16*). Twenty-one 30-foot rows were planted with the varieties Full Measure, Burpee Stringless Green Pod, and Venezuelan Black—three bush varieties of demonstrated worth for this locality. Every alternate row was planted with Venezuelan Black beans. The plants were spaced 4 inches apart in the row. The crop was picked weekly at the snap-bean stage. The lowest yield of any row of Venezuelan Black was more than double that of the best row of either of the other varieties, which, however, far excel it in quality. Expressed in ounces, the production of pods per linear foot of row was 9.4 for Venezuelan Black, 2.3 for Burpee Stringless Green Pod, and 2.1 for Full Measure. Twenty-one 50-foot rows were sown with pole varieties. The resultant plants were thinned to 6 inches apart in the row. Exclusive of outside rows, there were five rows each of Kentucky Wonder and White Creaseback, and three each of Horticultural, McCaslan, and Burger Stringless Green Pod. White Creaseback was the most productive, and Kentucky Wonder ranked second in production. The superior table quality of the latter, however, more than compensated for the difference in yield. The average production of each variety, expressed in ounces per linear foot of row, was 6.8 for White Creaseback, 5.9 for Kentucky Wonder, 4.2 for McCaslan, 3.6 for Burger Stringless Green Pod, and 0.9 for Horticultural. The two most productive pole varieties were two and a half to three times as productive as the northern bush varieties grown in adjacent rows contemporaneously with them.

ROOT CROPS

SWEETPOTATOES

A comparative planting of sweetpotato varieties was again made. Key West, Nancy Hall, Florida, White Yam, Southern Queen, Porto Rico, and Harvey, a local variety, were planted on $\frac{1}{100}$-acre plats and dug at 6½ months. A plat of Key West as a check was adjacent to each plat of the other varieties. Key West made an average produc-

tion of 195 pounds of roots per plat. The other varieties produced only from 42 to 83 per cent as much as the adjacent Key West check. The order of decreasing production, expressed in percentage of the check, was 83 for Florida, 75 for White Yam, 73 for Southern Queen, 59 for Harvey, 52 for Nancy Hall, and 42 for Porto Rico. Of the many sweetpotato varieties introduced and tested by the station, Key West has been found to be the most prolific. It has been distributed throughout the island. In addition to distributing sweetpotato roots to planters for propagation, the station grew and distributed approximately 12,000 slips.

DASHEENS, TAROS, AND YAUTIAS

Dasheens and the Penang variety of taro were planted in April and dug at monthly intervals ranging from 5 to 11 months after planting was done. Corms and tubers were edible at 5 months, although they were too immature for market purposes. The dasheens were sufficiently developed at 6 months for shipping, but maximum production occurred 9 to 11 months after planting. The maximum production of Penang taros occurred 11 months after date of planting. The dasheen is commercially promising, because of heavy production and good keeping quality, whereas the Penang taro is much less so, owing to its perishability. It, however, furnishes an excellent food for home consumption, and in table quality is much superior to the dasheen. Some 7,000 tubers of dasheens, taros, and yautias were distributed for propagation.

FLOWERS

A flower show was held in San Juan in February. The station cooperated by displaying the blossoms of numerous hibiscus varieties, Philippine wax flowers (*Phaeomeria speciosa*), and a large assortment of sweet peas—a flower that is seldom grown locally. Many of the hibiscus varieties had originated at the station, and they were pronounced the most interesting of the exhibits. Varieties of hibiscus originating at the station are now to be seen growing over all parts of the island, and the distribution is being continued.

REPORT OF THE PLANT BREEDER

By R. L. Davis

FIELD CORN

The objectives in corn breeding for the year 1930 were (1) to isolate corn varieties typical in different districts, for making first-generation hybrids; (2) to continue inbred lines from various districts; and (3) to increase the seed supply of the more vigorous lines for use in hybridization.

COLLECTION OF VARIETIES FOR MAKING FIRST-GENERATION HYBRID SEED

Corn seed was collected in various parts of the island for making first-generation hybrids with prepotent selfed lines. Special effort was made to secure seed that had been grown for a number of years

in the same locality, and studies of the types of corn collected were made. A number of types distinct from one another were isolated. In one instance two different corn varieties were obtained near Aguadilla from farms only 1 mile apart. One of the varieties was especially promising for its uniform long ears of a dent type.

Corn seed was collected from 10 different farms located in Barranquitas, Coamo, Yauco, Guayanilla, Peñuelas, San Sebastian, Isabela, and Aguadilla. Plans for producing and testing hybrid seeds were made in cooperation with the insular experiment station and with the Central Coloso. As far as was practicable, the aim was to produce hybrid seed in a locality similar to that in which the test was to be made.

INBREEDING

Inbreeding was continued from high-yielding parent ears from the various districts, including Barranquitas, Aibonito, Jayuya, Coamo, Morovis, Lajas, and Peñuelas. In order to secure good seed supplies for hybridizing, 15 to 20 plants were self-pollinated in each

FIGURE 5.—Field-corn-breeding plat in which 499 plants were bagged for self-pollination. The workman in the picture is over 6 feet tall

of the more promising lines. A general view of one of the corn-breeding plats is shown in Figure 5. Four hundred and ninety-nine plants were bagged for self-pollination in this plat, and 253 were bagged in another plat. Each row is a separate inbred progeny. The man standing in the corn plat is over 6 feet tall. Several of the lines next to him are fifth- and sixth-generation inbreds and still approach normal open-pollinated corn in height.

The bag withdrawal method was devised in order to reduce the supervision required in the self-pollination process. The well-known bottle method was used, but instead of removing the ear bag upward, as is customary, thus tending to expose the silks, it was ripped open and pulled straight downward after the tassel bag and the tassel were in position. Each ear bag used was slit open at the bottom in preparing for the selfing process. The bottom was then doubled over several times and fastened with clips. Just before pollination took place the clips were removed. By a gentle pull from below, the ear bag was ripped open and withdrawn, leaving the tassel in contact with the silks and the tassel bag in position. The use of the bag-

withdrawal method enables the worker to remain 4 to 6 inches from the silks and safeguards them against hand touching and contamination with foreign pollen.

Selfed lines derived from Barranquitas continue to be less desirable in grain production than those from other districts. They are characterized by open husks which expose the ends of the ears and cause rapid decay under heavy tropical rainfall.

Aibonito derivatives include third-generation progenies from the parent ear Aibonito–4. With the exception of Aibonito–4–15–Sib.–1, which approached normal corn in height, the Aibonito lines are lacking in vigor.

The Coamo derivatives are of special interest, as several sister lines from Coamo–12–13–1–1 exceed normal corn in ear length. Selection is being made for a long flinty ear.

Lines from Lajas, Jayuya, and Peñuelas have been inbred over a longer period of years than those from other districts. The approach to uniformity is illustrated in Figures 6, 7, and 8.

In Figure 6 are shown two Jayuya lines. The one above VF–2–4–1–2–3–4 is approaching uniformity for long shanks and flinty kernels, whereas the one below is a short-shanked creased dent type.

Figure 7 shows three lines from Lajas. The one above, C–1–67–1–1–5–1, which has been inbred for five generations, is a white line practically uniform for creased dent kernel type, ear length, and plant height. The two lines shown below are still segregating for kernel type. They are chiefly of interest as affording material for selection toward a deeply creased dent type. C–1–50–1–5, in the lower right corner of the figure, is being discarded because of diseased cobs and discolored kernels.

Figure 8 shows two Peñuelas lines having marked uniformity in kernel type, ear length, and shank length. This is an unusually rapid approach to uniformity for lines which have been inbred for only three generations.

Progress in selection during the reduction process may be summarized as follows: VF–2–4–1–2–3–4, a line with flinty ears of normal length and very long shanks is being isolated from Jayuya. The best derivative from Lajas, C–1–67–1–1–5–2, is rapidly approaching uniformity for white, creased dent, 14-rowed, short ears. Derivatives from Barranquitas and from Lares are generally unhealthy and most of them are being discarded. Two sister lines from Coamo that almost breed true for very long ears and round, flinty kernels lack only one or two generations of inbreeding and selection to establish them as homozygous breeding stock. Lines from Morovis are still very heterozygous. Peñuelas lines derived from the parent ear Castillear–1 continue to make vigorous plant growth after five generations of selfing and are very slow in reaching uniformity.

SWEET CORN

Mayaguez–1 sweet corn was tested by Owen Proverbs of Hormigueros, F. T. Maxwell of Ensenada, Rafael Bermudez of Fajardo, and A. L. Foss of Aguirre. These planters were of the opinion that the ears were rather small. At Homigueros this variety was grown on a dry hillside and the ears were 4 to 6 inches long, fairly sound,

and edible. Experience at Mayaguez over a long term of years shows that sweet-corn seed from the continental United States produces ears that are very small and are severely attacked by worms.

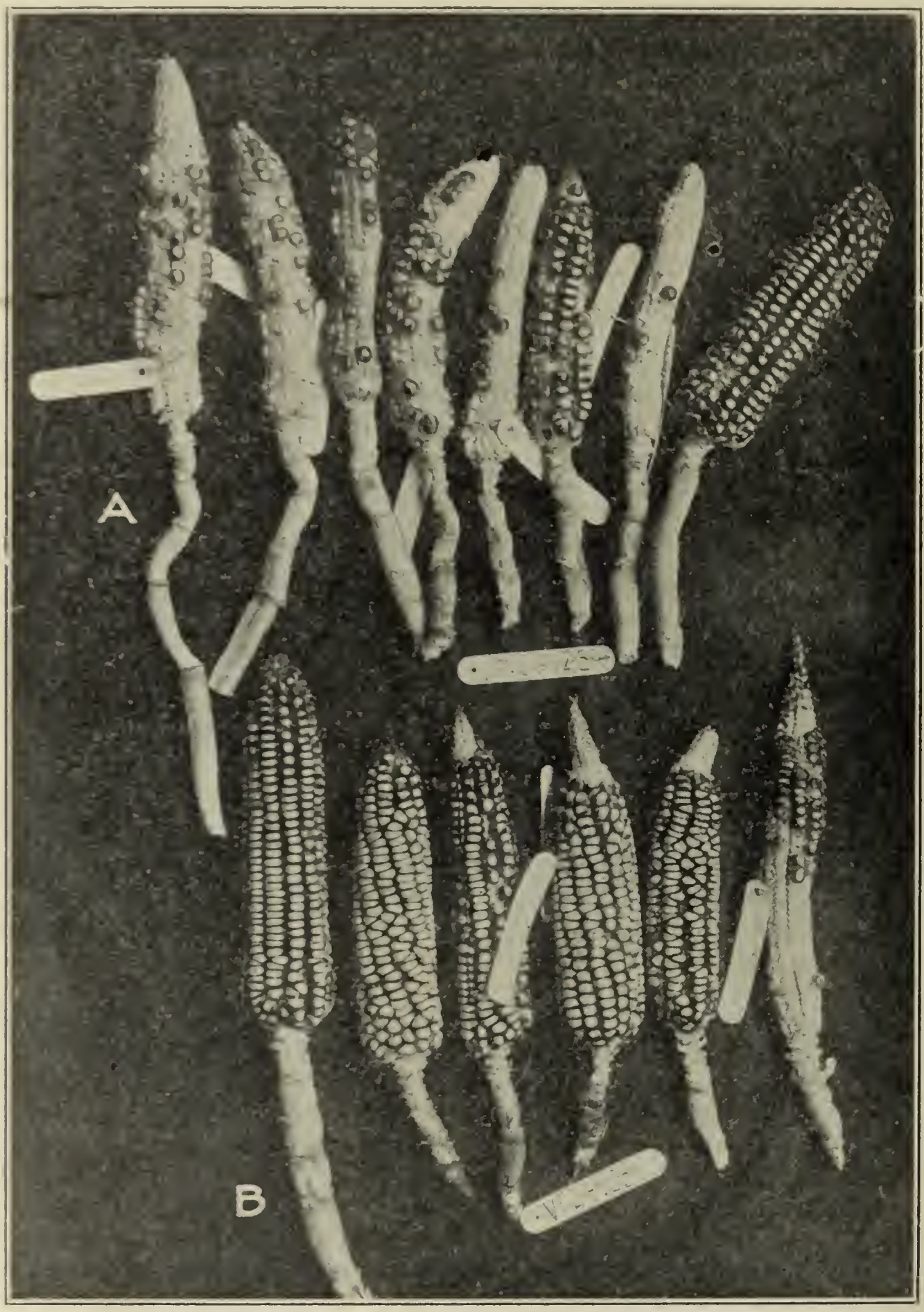

FIGURE 6.—Jayuya lines of corn showing positive results of selection for long shanks and large, creased dent kernels: A, VF–2–4–1–2–3–4 progeny with shanks 12 to 20 centimeters long, flinty to dimpled dent kernels, and tapering 12- to 10-rowed ears 15 to 19 centimeters long; B, VF–2–4–1–2–3–1, a sister progeny with short, stocky shanks, large, creased dent kernels, and tapering ears varying in row number from 8 to 14

First-generation crosses between Mayaguez–1 and the more vigorous starchy selfed lines were grown. All flinty ears of the Xenia generation were discarded on the assumption that selection for tender kernels would be more likely to succeed in a sweet corn crossed with

a dent corn. The sweet-corn-breeding plat of May, 1930, is shown in Figure 9. Over 400 plants were bagged for self-pollination. The kinds of corn tested included Mayaguez–1, 3 first-generation hybrid sweet corns, 2 first-generation hybrids between Mayaguez–1 and the most vigorous starchy lines, 5 open-pollinated sweet-corn selections, 9 selfed lines from Mayaguez–1, and another native sweet-corn strain.

A study was made of the condition of the silks to determine the best time to harvest green corn for table use. Corn was found to be too young for harvesting as long as any of the silks were living and resisted being pulled away from the tip of the ear. When the corn was harvested within a day or two after all the silks had de-

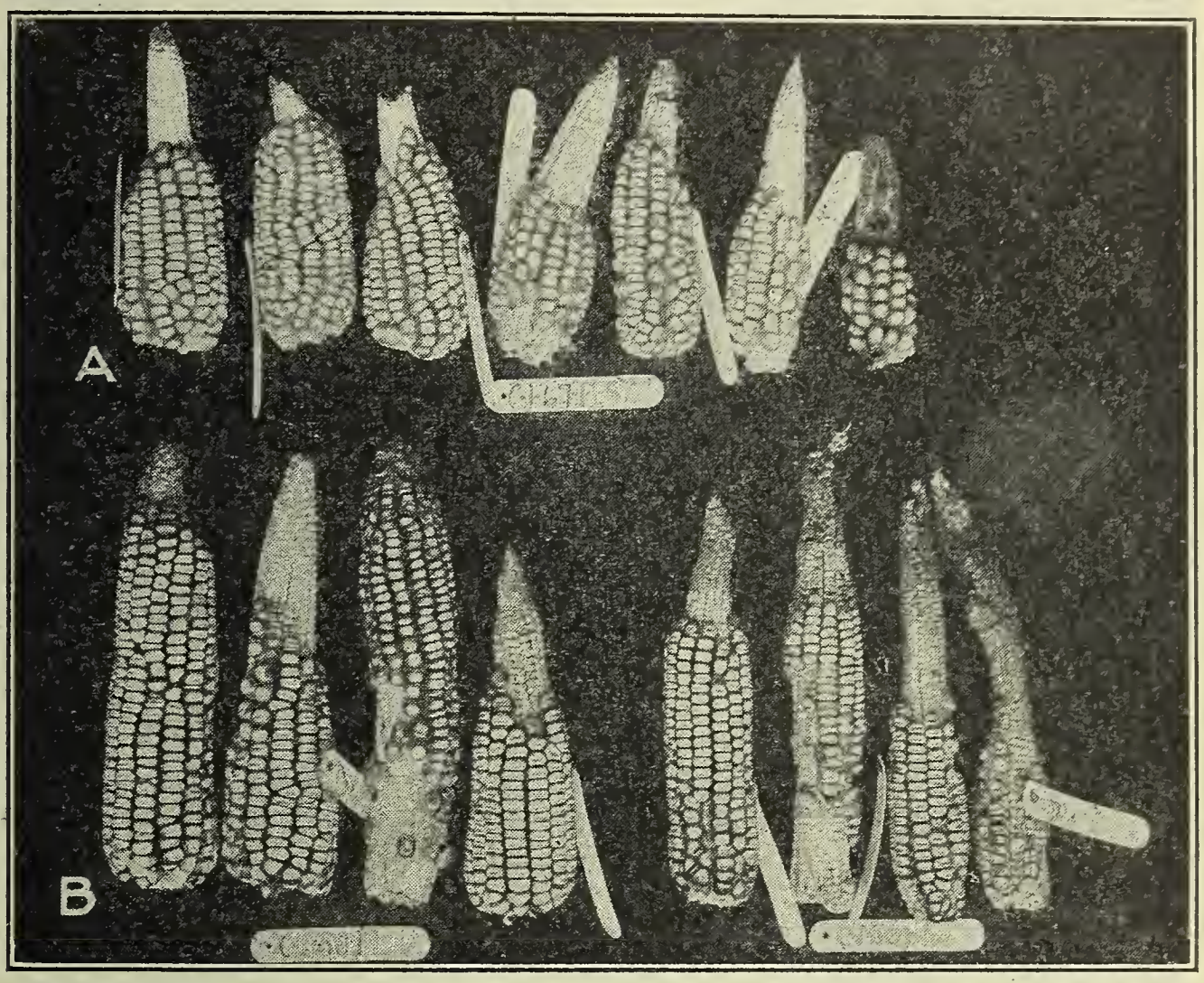

FIGURE 7.—Three lines from the same Lajas parent ear of corn, showing approach to uniformity in creased dent type of kernel and ear length: A, C–1–67–1–1–5–2 progeny has short ears, 14 to 16 centimeters long, white, creased dent kernels and healthy cobs, and makes large plant growth; B, two sister progenies which breed true for long ears, but are less uniform in kernel type. C–1–50–1–1, on the left, has 14-rowed tapering ears 18 to 22 centimeters long, tightly clasping husks, large, well-filled kernels, and healthy cobs, and is far superior to C–1–50–1–5, on the right, which is being discarded because of poorly filled, diseased kernels, and diseased cobs

cayed, the kernels were found to be well filled but tender and suitable for eating.

COVER CROPS

Preliminary experiments were made in comparing Hawaii Hybrid No. 1383 with four varieties of cowpeas which grow well in the southern part of the United States. Late plantings were made July 15 to determine which varieties would withstand very heavy rain and tropical heat. Hawaii Hybrid No. 1383 covered the ground much more rapidly than did the other varieties. On December 8 it was still green and growing vigorously. The vines were 3 to 6 feet

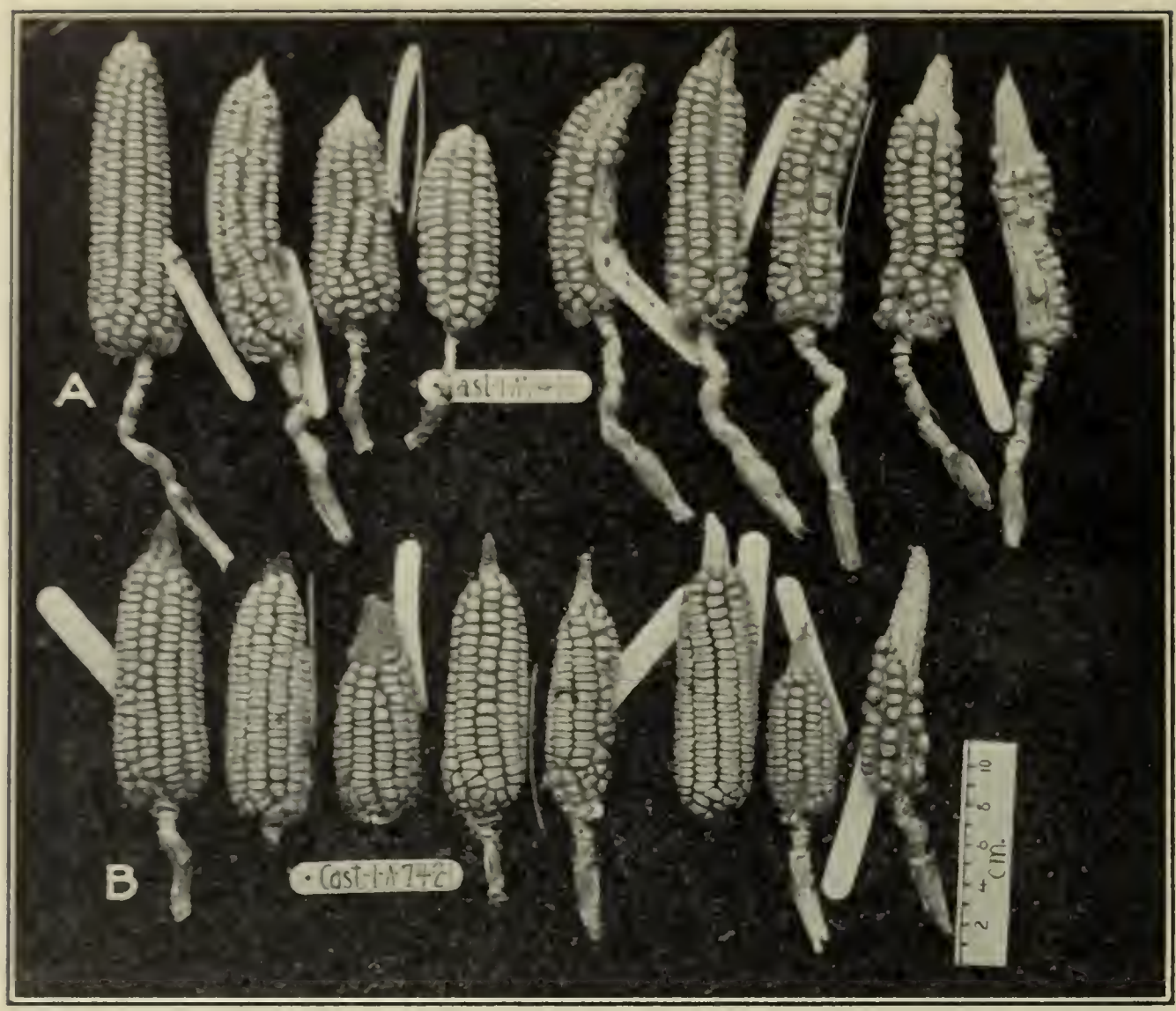

FIGURE 8.—Two sister progenies from a high-yielding ear of corn collected at Peñuelas show uniformity in length of shank, number of kernel rows, and type of kernels. Each ear has been self-pollinated and inbred for four generations: A, Cast.–1–o.–p.–74–1–1 ranges in row number from 8 to 10, in length of shank from 0.5 to 3 inches, and in type of kernel from deeply creased dent to creased dent B, Cast.–1–o.–p.–74–2–1 ranges in row number from 10 to 12, in length of shank from 0.5 to 3 inches, and in type of kernel from deeply creased dent to creased dent

FIGURE 9.—Sweet-corn-breeding plat. Over 400 plants were bagged for self-pollination. The corn plants on both sides of the workman are first-generation hybrids between the best starchy inbred lines and Mayaguez–1 sweet corn. Photographed July, 1930

long and bore an average of 3 well-filled pods each. It is much later in maturing than are the other varieties tested, and should be grown more extensively in other parts of the island in competition with native-grown seed. The Brabham variety ranked next to Hawaii Hybrid No. 1383. The vines averaged 2 to 3 feet long, and produced 1 to 2 well-filled pods each. The variety is much earlier than Hawaii Hybrid No. 1383. The Iron variety was a poor third with vines 1½ to 2 feet long and only 1 to 2 poorly filled pods each. The Groit variety produced vines 2 to 3 feet long which were half yellow. Only 1 pod per plant developed. The Columbia cowpea was a failure, the vines being only 6 to 12 inches long.

SUGARCANE

TESTS OF INTRODUCED VARIETIES

The plant breeder, in company with the station pathologist, visited districts near the towns of Coloso, Humacao, Fajardo, Rio Piedras, Los Caños, Arecibo, Isabela, Yauco, Guayanilla, Santa Rita, and Hormigueros for the purpose of determining the prevalence and kind of sugarcane diseases there and of giving advice on the best methods of propagating valuable and recently introduced varieties of sugarcane. Many fields of P. O. J. 2878 were inspected in all parts of the island and found to be free from mosaic. Some trace of the pokkah boeng disease was observed in P. O. J. 2878, but usually only one or two leaves on a plant were attacked, and the cane recovered without any apparent setback in growth. This disease is not regarded as commercially important in Porto Rico. The variety P. O. J. 2878 is of special merit, and has been widely adopted on the island.

The area in P. O. J. 2878 cane totals 1,213 acres for the 1931 crop, and 3,405 acres for the 1932 crop. The extension has largely developed from cuttings distributed by the station. During the year 4,446 cuttings were distributed to 137 cane growers and to 25 of the local sugar centrals. P. O. J. 2878 has a tendency to uproot under moderately strong winds, and for this reason its extension has been limited in some districts. Many favorable reports concerning it have been received, however. One farmer near Mayaguez states that P. O. J. 2878 yields from 35 to 42 tons of cane per acre on hillside land on which formerly only Uba cane could be grown with a yield of 16 to 18 tons of cane. He also estimates that a ton of P. O. J. 2878, because of its higher sucrose content, is worth $8.50, whereas Uba is worth only $5 or $6 per ton. Near Lajas and Coloso P. O. J. 2878 can be harvested at less cost than other varieties because it makes erect growth, sheds its leaves freely, and produces canes of large diameter.

P. O. J. 2878 ratoons excellently as is shown in Figure 10. This 22-acre field of 14-month-old ratoons at Central Coloso arrows sparingly and is estimated to be the best of all the fields under culture in 1931. This is a remarkable showing when it is considered that the spacing was 3 by 5 feet and that one single-eye cutting was planted to a hole in the original planting. A count of 17 canes per stool was obtained for the edge of the field shown. The proportion of arrowing along the edge was 5 to 10 per cent, whereas in the center of the field it was still less. These ratoons were grown without irrigation in a loose, rich alluvial type of soil. The prolific stooling that re-

sulted from such a reduced planting rate is indicative of its strong ratooning power.

The South Porto Rico Sugar Co. is planting P. O. J. 2878 almost to the exclusion of any other cane variety in the districts of Hormigueros and Añasco. The high cost of rogning out mosaic from plats of B. H. 10 12 has necessitated replacing that variety with an immune kind, such as P. O. J. 2878. This company has 219 acres of land planted with P. O. J. 2878 for the 1931 crop, and 600 acres planted for the 1932 crop in the two districts. Under the conditions of drought that prevailed for several months after planting was done, gran cultura [6] plantings of P. O. J. 2878 closed one and one-half to two months earlier than similar plantings of B. H. 10 12 at Filial Amor in the Hormigueros district, indicating that the cost of cultivating P. O. J. 2878 would probably be less than for B. H. 10/12.

FIGURE 10.—P. O. J. 2878 gran cultura sugarcane ratoons. The variety made excellent growth in a long first-ratoon crop at Coloso and arrowed sparingly

P. O. J. 2883 was also propagated during the year, but was not distributed because of its susceptibility to mosaic. It should make more desirable breeding stock than P. O. J. 2725, since, unlike the latter, it does not arrow early.

DISTRIBUTION OF MAYAGUEZ MOSAIC-RESISTANT SEEDLINGS

Approximately 11,500 cuttings of Mayaguez seedlings Nos. 3, 7, 42, and 63 were sent in equal lots to five large local sugar centrals for trial. Approximately 4,000 additional cuttings of these seedlings were distributed in smaller lots to several hundred farmers and to all the centrals on the island. From the first-mentioned distribution, 72.8 acres of land have been planted with the Mayaguez seed-

[6] Summer or fall plantings of cane are usually allowed to grow for 15 to 18 months before being harvested, and are termed "gran cultura" plantings.

lings and their increase for the 1932 grinding season, including 20 acres each of Mayaguez seedlings Nos. 7 and 42; 3 acres of Mayaguez 3; 4.55 acres of Mayaguez 49; and 25.7 acres of Mayaguez 28. Mayaguez 42 is looked upon with great favor in the Arecibo district where the Soller Sugar Co. is using the single-eye method to propagate the variety rapidly.

USE OF THE HAND REFRACTOMETER

The hand refractometer was used for the first time at Mayaguez for preliminary testing of first-year seedlings. A composite sample of the juice from the middle joints of five canes per stool was collected and compared with a similar sample from adjoining stools of P. O. J. 2725. Instead of collecting the samples by sawing out sections of the cane and squeezing out the juice later with a pair of pliers, as is done in Hawaii, the juice was extracted by means of an ice pick and collected on tissue paper. The ice pick was thrust into the cane and worked up and down to force out the juice, which was absorbed by the tissue paper held below. When the tissue paper was saturated the juice was squeezed onto the glass surface of the refractometer. The reading was immediately taken and compared with that from the P. O. J. 2725 check row. Of 27 seedlings giving a refractometer reading below 15 per cent of total solids December 4, one-half analyzed under 16 per cent of sucrose in a hand-mill test February 11. Of 23 seedlings that gave refractometer readings of 15 per cent of total solids, or over, only 4 analyzed under 16 per cent of sucrose at the later date. The hand-refractometer readings and the hand-mill analyses varied considerably as was to be expected from the use of small samples. It is hardly safe to discard any but the very poorest seedlings when the hand refractometer is used.

COOPERATIVE SINGLE-ROW TRIALS AT GUAYANILLA AND AT HORMIGUEROS

Alternate single-row trial plantings of third- and fourth-year Mayaguez seedlings, with B. H. 10/12 as the check variety, were begun in October, 1928, in cooperation with the Central Rufina at Guayanilla, and with the South Porto Rico Sugar Co. at Hormigueros. The principal objectives were to make preliminary sucrose analyses and to observe mosaic infection. On December 19, 1929, Mayaguez seedlings Nos. 28, 42, 44, and 48 at Hormigueros analyzed 3 to 4 per cent higher in sucrose than P. O. J. 2725, and 1 to 2 per cent higher than B. H. 10/12. On January 10, Mayaguez seedlings Nos. 42, 44, and 49 exceeded B. H. 10/12 in sucrose by 1 to 3 per cent. Mayaguez seedlings Nos. 42, 48, and 52, showed no mosaic infection and Mayaguez seedlings Nos. 28, 44, and 49 a negligible amount. With the exception of Mayaguez 28, all the seedlings show marked improvement over the mother parent, P. O. J. 2725, as they either do not arrow at all or arrow much later. Early arrowing is the chief drawback to this Javan variety. The high sucrose analyses secured in December and in January are especially desirable as indicating the probable extension of the grinding season through the development of an early ripening cane. Table 1 gives the hand-mill analyses of the canes.

73200—31——4

TABLE 1.—*Composition of the juice of different Mayaguez seedlings of sugar-cane, with B. H. 10/12 as the check variety, grown in alternate single rows at Hormigueros, Guayanilla, and Mayaguez* [1]

Where grown, age of plant, variety, and date of analysis	Sucrose	Purity
South Porto Rico Sugar Co., Hormigueros; "gran cultura" [2] plantings 14½ months old, Dec. 19, 1929:	*Per cent*	*Per cent*
P. O. J. 2725	15.96	85.50
Mayaguez 42	18.76	86.50
B. H. 10/12	16.70	89.70
Mayaguez 28	18.51	91.60
Mayaguez 44	19.25	91.00
Mayaguez 47	15.67	85.50
Mayaguez 48	17.56	88.40
B. H. 10/12	17.59	89.20
Mayaguez 49	16.92	87.80
Mayaguez 51	16.86	87.80
P. O. J. 2878	16.85	86.30
"Gran cultura" plantings 15 months old, Jan. 10, 1930:		
Mayaguez 42	18.86	91.70
Mayaguez 49	18.27	91.50
P. O. J. 2878	17.88	90.00
Central Rufina, Guayanilla; "gran cultura" plantings 19 months old, Jan. 10, 1930:		
Mayaguez 42	17.48	89.30
B. H. 10/12	[3] 15.47	85.30
Mayaguez 44	18.45	90.20
Mayaguez 49	[3] 16.69	87.70
P. O. J. 2878	15.58	83.50
Mayaguez 42	17.71	89.30
The station, Mayaguez; "primavera" [4] plantings 11 months old, Jan. 4, 1930:		
Mayaguez 3	17.59	88.40
Mayaguez 7	16.90	85.90
P. O. J. 2725	14.48	83.00
Mayaguez 42	17.85	90.00
B. H. 10/12	15.20	92.70
Mayaguez 28	17.13	86.50
P. O. J. 2878	16.87	88.20

[1] The small laboratory hand mill was used to extract the juice.
[2] Summer or fall plantings of cane usually allowed to grow for 15 to 18 months before being harvested.
[3] All canes were lying down. Ten to 15 canes from the same number of stools were collected as samples.
[4] Spring planting of cane usually cut when 12 to 13 months old.

BREEDING

First-Year Seedlings

New seedlings include crosses between U. S. 541 and B. H. 10/12 (742), U. S. 541 and S. C. 12/4 (7,858), U. S. 541 and P. O. J. 2878 (360), P. O. J. 2725 and U. S. 541 (396), P. O. J. 2725 and U. S. 785 (395), Mayaguez 28 and P. O. J. 2878 (250), B. 6835 and P. O. J. 2878 (70), B. H. 10/12 and P. O. J. 2878 (613), B. H. 10/12 and S. C. 12/4 (125), P. O. J. 2725 and B. H. 10/12 (873), and U. S. 541 and U. S. 785 (500). Of these seedlings, 11,822 were potted in bamboo containers. This is the largest number of seedlings ever potted out at Mayaguez in any one season. A large proportion of these seedlings contain Kassoer "blood," a fact which makes the season's output noteworthy.

The progenies of U. S. 541 and B. H. 10/12, U. S. 541 and S. C. 12/4, U. S. 541 and P. O. J. 2878, B. H. 10/12 and P. O. J. 2878, and B. 6835 and P. O. J. 2878 proved to be largely selfed seedlings. In crosses having U. S. 541 as the mother parent selfed seedlings may readily be distinguished by the very narrow leaves and very thin canes. Only two seedlings of U. S. 541 and B. H. 10/12 and 50 seedlings of U. S. 541 and S. C. 12/4 were retained. Where B. H. 10/12 and B. 6835 were used as the mother parents in combination with cane varieties containing Kassoer blood, a striking contrast

is also afforded between selfed seedlings which stool very poorly, develop slowly, and are very susceptible to drought, and hybrid seedlings which are prolific, develop rapidly, and as a rule are drought resistant. Only one seedling of P. O. J. 2878 and B. H. 10/12 proved to be a hybrid. The seedlings of B. 6835 were discarded.

The progeny of Mayaguez 28 and P. O. J. 2878 was planted in the row immediately adjoining that of B. H. 10/12 and S. C. 12/4. At five months the former seedlings were resisting the drought, taller than the latter, and definitely superior in stooling habit. Twenty-five seedlings of Mayaguez 28 and P. O. J. 2878 were selected for further trial. They are regarded as hybrids because they grow rapidly and many of them are erect like P. O. J. 2878, whereas selfed seedlings of Mayaguez 28 grow very slowly and are very spreading in habit. The seedlings of B. H. 10/12 and S. C. 12/4 were discarded.

The progenies of P. O. J. 2725 and U. S. 785 and P. O. J. 2725 and U. S. 541 have been retained for further study because P. O. J. 2725 is largely self-sterile and most of the seedlings are hybrids. U. S. 785 appears to be the more desirable as a parent, since in combination with P. O. J. 2725 its seedlings developed much more rapidly and had thicker canes than was the case with the seedlings of P. O. J. 2725 and U. S. 541. The canes of U. S. 785 are thicker than those of U. S. 541—a character that is transmitted.

The progeny of P. O. J. 2725 and B. H. 10/12 was not as vigorous either at Central Fajardo or at Mayaguez as the seedlings of P. O. J. 2725 and S. C. 12/4. These seedlings were produced at Paraiso in cooperation with the Fajardo Central experiment station under the direction of Rafael Bermudez. Cuttings were taken from 65 of the former progeny for second-year study.

First-year seedlings of P. O. J. 2364 and Mayaguez 9 were spaced 3 feet apart in rows 5 feet apart. In every fourth row stools of P. O. J. 2725 were transplanted to serve as checks. At the time the seedlings were transplanted boxes containing mosaic-infected Java (P. O. J.) 36 canes were set 15 feet apart along the rows.

Some of the seedlings were divided at time of transplanting into three groups. Group 1 was of superior size at 17 days, Group 2 was of superior size at 4½ months, and none of the seedlings of Group 3 were eliminated. In February, 1930, the average weight per stool of the 172 seedlings that were not selected was 16.7 pounds, or 37.7 per cent less than that of the 150 stools of the P. O. J. 2725 adjacent check rows. The yield of the 105 seedlings that were selected for superior size at 17 days was 22.1 pounds per stool, or slightly more than the P. O. J. 2725 check rows. The 202 seedlings noted as superior at 4½ months yielded 20.5 pounds per stool, or 27.4 per cent less than the check. In average weight the seedlings selected for early superiority had an advantage over those from which none were eliminated.

A better criterion for comparing these groups of seedlings is the relative proportions of seedlings retained for second-year trial. From 284 unselected seedlings that had been set in the field, 16, or 5.6 per cent, were chosen for second-year trial. Of the 154 seedlings of superior size at 4½ months, 12.67 per cent were retained. Assuming that only a limited area of land and a large number of first-year seedlings are available, elimination can be advantageously practiced at time of transplanting to the field. Elimination at 17 days offers

little advantage over elimination at 4½ months; but, nevertheless, elimination is desirable at 1 month or less if, as often happens, pots for transplanting are limited in number.

The range for average number of canes and shoots per stool was 15 to 16 for the P. O. J. 2725 check rows, and 12 to 13 for Mayaguez 9. Grown under the same conditions, Mayaguez 104 produced 17 canes and shoots which were somewhat smaller in girth than those of P. O. J. 2725, but weighed 47.6 pounds, or 75 per cent more than the latter. Of the 55 seedlings selected for second-year trial, nearly all equaled or exceeded P. O. J. 2725 in number of canes and shoots. Seedlings that were outstanding for prolificacy in the first year included Mayaguez 129 with 19 canes and shoots, Mayaguez 151 with 26, and Mayaguez 144 with 23. These preliminary trials indicate that a considerable proportion of this progeny of seedlings will compare well with P. O. J. 2725 in ratooning ability.

On September 1 measurements were taken of the diameter and the height to the highest leaf triangle, and averages were secured for five canes of each promising seedling. At this time Mayaguez 104 averaged 188 centimeters tall, or 2 centimeters less than P. O. J. 2725; Mayaguez 129 averaged 205 centimeters tall, or 8 centimeters more than P. O. J. 2725; and Mayaguez 189 averaged 217 centimeters tall, or 20 centimeters more than the check. As is always the case, complete arrowing occurred in P. O. J. 2725, whereas most of the seedlings of approximately the same height did not arrow or show any sign of arrowing.

The average cane diameter of the P. O. J. 2725 check rows ranged from 3.6 to 3.8 centimeters. Most of the seedlings ranged from 3 to 3.3 centimeters in cane diameter, and are apparently somewhat smaller in girth than P. O. J. 2725. Judging by the average cane girth of 25 canes of B. H. 10/12 grown in the same field, which was 3.2 centimeters, these girths will prove to be satisfactory in subsequent trials, and too rigorous elimination on the basis of cane thickness is not desirable.

Second-Year Seedlings

Second-year trials were made with seedlings of P. O. J. 2364, pollinated with Mayaguez 9. In September, when these first-year seedlings were 8½ months old, 32 of the more promising kinds were planted in 2-row plats alternated with P. O. J. 2878. The germination of 580 cuttings of these seedlings was 96.9 per cent. The early growth of a number of the seedlings compared well with that in adjoining rows of P. O. J. 2878. The average height of the 16 tallest shoots, measured to highest leaf tip at 3½ months, was 171 centimeters for Mayaguez 32, and 175 centimeters for Mayaguez 151, whereas P. O. J. 2878 did not average more than 160 centimeters in any part of the field. In number of shoots per 16 stools, P. O. J. 2878, with 77 to 90, was barely equal, or was inferior, to Mayaguez 132 with 97 shoots, Mayaguez 151 with 94 shoots, Mayaguez 145 with 84 shoots, and Mayaguez 163 with 76 shoots. Twenty canes of P. O. J. 2878 grown in different parts of the field ranged in average diameter from 3 to 3.25 centimeters. Mayaguez 132, with an average diameter of 2.78 centimeters, was somewhat inferior to P. O. J. 2878, whereas Mayaguez seedlings Nos. 145, 151, and 163 were well within

the range of cane size for P. O. J. 2878. Mayaguez 151 was less variable in cane size than P. O. J. 2878, and averaged 3.3 centimeters, or slightly larger in girth than the latter.

In January hand-refractometer readings were taken from samples collected from the middle joints of five canes from each first-year seedling of P. O. J. 2364 and Mayaguez 9. Samples were also analyzed one month later by means of the polariscope and the Brix hydrometer. All seedlings that did not approach the readings secured on adjoining rows of P. O. J. 2725 were discarded. The retained seedlings were planted in two fields for study of the stooling habits and for mosaic elimination.

The same varieties as those grown in the mosaic-elimination plat were planted in the field to test stooling habits. The rootstocks of the original first-year seedling stool were divided into five equal parts and planted in the front half of the row. Single-eye cuttings were transplanted to the rest of the row after they had sprouted and were 6 to 8 inches tall. The plants were spaced 3 feet apart in rows 5 feet apart. Irrigation water was applied, but was not adequate for full development of the plants. On June 9 counts were made of the number of shoots and canes per stool. The more prolific seedlings were Mayaguez seedlings Nos. 104, 129, 132, 144, and 151, with an average of 10.5 to 11.8 shoots per single-eye stool. Of these five seedlings, Mayaguez 129 was superior in first ratoons, with an average of 9.7 shoots per rootstock. Mosaic attacked only those seedlings that had become infected in the mosaic-elimination plat.

A fall planting of Mayaguez 151, which appeared to be the most promising of the series, was propagated by the single-eye method. Approximately 300 stools were secured, and by August enough cuttings to plant an acre of land were available. In less than two years from the time of collecting the arrows, Mayaguez 151 has reached the stage of small commercial trial plantings. This variety is unquestionably commercially immune [7] to mosaic, since infection has not been observed in the 300 stools notwithstanding the fact that they were grown adjacent to mosaic-infected cane.

In the second-year trial for seed production and mosaic elimination, the hybrids of P. O. J. 2364 and Mayaguez 9 were planted in 75-foot rows. Two stools of mosaic-infected Java (P. O. J.) 36 cane were planted at each end of the rows. Rows of Honey Drip sorghum were then sown in the spaces intervening between infected stools and the stools of the other varieties. The Honey Drip variety of sorghum is very susceptible to mosaic and is a better host for the corn aphid than is ordinary field corn. Sorghum has been used successfully as a mosaic vector in Cuba. A general view of the mosaic elimination plat when 6 months old is shown in Figure 11. At the time the photograph was taken only 5 out of 55 seedlings had developed mosaic. The slow spread of the disease indicates that most of the seedlings are mosaic resistant. In only one instance did the shoots of an entire stool become infected. Most of the seedlings compare favorably with B. H. 10/12 in cane girth. Of 2,500 seedlings in the original test, all but these 55 have been discarded because of a lack in vigor or susceptibility to mosaic.

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[7] By the phrase "commercially immune" is meant a high degree of resistance to mosaic infection, any such disease developing being not difficult or expensive to rogue.

Of the 55 seedlings planted in the mosaic-elimination field, 16 were susceptible or resistant at maturity, and the other 39 did not become infected and apparently are immune to the disease. In the latter group, 6,280 canes were examined and found to be entirely free from mosaic. In only one instance did an entire stool become infected, and in no instance did the infection spread from one end of an infected long cane to the other. Half the susceptible seedlings were infected in less than 1 per cent of the canes, and among the other eight susceptible seedlings only three had an infection above 3 per cent. The heaviest infections were in Mayaguez seedlings Nos. 111, 222, and 249, with 4.4, 9.2, and 9.6 per cent of infection, respectively. Serious stunting in infected cane was noticed only in Mayaguez 249. The proportion of infection in a total of 3,043 canes observed in the susceptible lot was 1.94 per cent. This is a very low percentage of

FIGURE 11.—Second-year trial with sugarcane for seed production and mosaic elimination from the hybrids of P. O. J. 2364 and Mayaguez 9. Although the mosaic-infected cane, Java (P. O. J.) 36, and the Honey Drip variety of sorghum were planted in each row to further the spread of the disease, only five seedlings had developed mosaic at six months

infection when it is considered that 35 to 40 per cent of the canes of each seedling of "noble" canes, such as S. C. 12/4 and B. H. 10/12, become infected when grown between infected stools of Java No. 36. The slow spread of mosaic infection from one stool to another, or from one portion of a cane to another, the large proportion, 71 per cent, of the 55 second-year seedlings that did not become infected, and the low percentage of infection in most of the infected seedlings indicate that most of the seedlings under trial are either wholly or at least commercially immune to mosaic. It is not always desirable to discard infected seedlings, because observations at Mayaguez and elsewhere show that some of them may be susceptible to mosaic in only a mild degree. This is apparently true of Mayaguez seedlings Nos. 28, 36, 44, 49, and 61. In instances in which infection has occurred in these four seedlings, the rate of spread from one stool to another has been very slow.

Third and Fourth Year Seedlings

Preliminary trials with Mayaguez seedlings Nos. 3, 7, 28, and 42, and with P. O. J. 2725 and B. H. 10/12, planted in alternate 4-row series with P. O. J. 2878 as the standard, were begun at Mayaguez in February, 1928. A strong wind uprooted many of the stools of P. O. J. 2878, and rendered tonnage data on this variety unreliable. The information gathered indicated a superiority of 5 to 15 tons of cane per acre for Mayaguez seedlings Nos. 3, 7, and 42 in comparison with P. O. J. 2725. Mayaguez 42 was especially outstanding, averaging 3 to 4 feet taller than the adjoining plat of P. O. J. 2878. No arrows or uprooted stools were observed in Mayaguez seedlings Nos. 3 and 42, whereas the growth of both P. O. J. 2878 and P. O. J. 2725 was interrupted by early arrowing. Mayaguez 7 arrowed later than P. O. J. 2878. Hand-mill analyses made January 4, 1929, confirm the results obtained at Hormigueros and at Guayanilla indicating that Mayaguez seedlings Nos. 3, 7, and 42 are high in sucrose, being superior in this respect to P. O. J. 2725 by 1 to 2 per cent. (Table 1.)

Cooperative Experiments

In September, 1929, gran-cultura plantings of Mayaguez seedlings Nos. 7 and 42 were made in cooperation with the Central Eureka, near Mayaguez. Triplicate plantings were made in alternate 2-row series with P. O. J. 2725. Each variety occupied a 0.185-acre plat. The season was dry and exceedingly adverse to germination. B. H. 10/12, grown on a small plat included in the experiment, had to be replanted, whereas the Mayaguez seedlings germinated satisfactorily. At 8 months both Mayaguez seedlings Nos. 7 and 42 exceeded the height of P. O. J. 2725 by approximately 1½ feet. No mosaic was then observed in these two crosses, although the proportion of infection in B. H. 10/12 and in S. C. 12/4, growing in close proximity, was 51.2 and 38.5 per cent, respectively. The cooperators are testing both seedlings more extensively. Figure 12 shows typical stools of Mayaguez 42, on the left, grown in comparison with P. O. J. 2725, on the right. Mayaguez 42 produces canes of large diameter, is immune to mosaic, and is sweeter than P. O. J. 2725. Mayaguez 42 does not blossom early, whereas P. O. J. 2725 has the objectionable feature of blossoming early. The former has grown more rapidly than the latter during the first eight months.

At Filial Amor gran-cultura plantings of Mayaguez seedlings Nos. 3, 7, 42, and 49 in alternate 2-row series with B. H. 10/12 as the check, were started in September, 1929, in cooperation with the South Porto Rico Sugar Co. Each variety occupied two $\frac{1}{30}$-acre plats. Conditions for germination were satisfactory, and B. H. 10/12 and Mayaguez 7 gave excellent stands. No mosaic infection was observed in Mayaguez seedlings Nos. 3, 7, and 42, although the disease in the adjoining plats of B. H. 10/12 averaged 21.02 per cent. Mayaguez 49 made a very favorable growth in comparison with B. H. 10/12, but was susceptible to mosaic. These seedlings at 6 months exceeded B. H. 10/12 by 4 to 8 inches in height and three to four in number of shoots per stool. The cooperators are extending the area planted to these seedlings.

At Añasco the South Porto Rico Sugar Co. has from $\frac{1}{10}$ to $\frac{1}{5}$-acre-plat plantings of Mayaguez seedlings Nos. 3 and 42, F. C. 916, B. H. 10/12, and P. O. J. 2725. Mayaguez 42 at 3 months was taller than any of the other varieties. The germination of Mayaguez 42 was 90 per cent, whereas that for F. C. 916 and P. O. J. 2725 was 78 per cent.

FIGURE 12.—Sugarcane varieties. A, Mayaguez 42; B, P. O. J. 2725. The former has grown more rapidly than the latter during the first eight months. The distance across the ditch is 1 foot

At Santa Rita the same company has $\frac{1}{20}$-acre-plat plantings of Mayaguez seedlings Nos. 36, 47, 52, and 62. Under conditions of drought these canes compared favorably with B. H. 10/12. At 10 months Mayaguez 36 was approximately the same height as B. H. 10/12 and was stooling better. The canes of this seedling exceeded in girth adjoining rows of B. H. 10/12. Mosaic infection in Mayaguez 36 was very low, indicating that this seedling is highly resistant

to the disease, as was previously noted at Mayaguez. Mayaguez 62 was shorter than B. H. 10/12 and less promising than Mayaguez 36. Mayaguez 47 proved to be susceptible to mosaic, and many of the stalks died. It is not considered to be worthy of further trial. Mayaguez 52 stooled much less than Mayaguez 36, but was healthier than Mayaguez seedlings Nos. 36 or 47, developing no mosaic. Mayaguez 36 is considered to be the most promising of these four seedlings since it is highly resistant to mosaic, is the best stooler, and grows to about the same height as the others.

At the Central Monserrate, Manati, where the drought was severe, Mayaguez 42 was reported to be resistant to drought and to grow more rapidly than the other varieties planted at the same time. The stooling also was regarded as satisfactory in the single acre of this variety under cultivation.

At the Central Mercedita, Ponce, Mayaguez 28 is regarded very favorably because of its ability to resist drought and because of its strong stooling habit. It is said to be superior in drought resistance to P. O. J. 2878, P. O. J. 2725, and S. C. 12/4 and to stool better than P. O. J. 2725. The cost of cultivating Mayaguez 28 was estimated at $3.75 per acre, whereas that for B. H. 10/12, grown under similar conditions, was upwards of $6.75.

At the Central Fajardo, at Fajardo, Mayaguez, seedlings Nos. 3 and 42 were planted in February, 1930, in alternate 2-row series with B. H. 10/12 as the check. Germination was excellent, and replanting was not necessary. Each variety occupied a $\frac{1}{20}$-acre plat.

At the Central Aguirre, Mayaguez seedlings Nos. 3, 7, 42, and 63 were planted in alternate 2-row series with B. H. 10/12 as the standard. Each variety occupied a $\frac{1}{20}$-acre plat. Mayaguez 7 and B. H. 10/12 gave excellent germination. Good germinations were obtained with Mayaguez seedlings Nos. 3, 7, and 42. The Javan method of replanting was used, extra cuttings being planted at the head ends of the rows and the resultant plants transplanted under irrigation. A perfect stand was secured, as is essential with small plat plantings. At 4 months all of the Mayaguez seedlings were growing well and compared favorably with B. H. 10/12.

At the Central Coloso, hillside plantings of Mayaguez 28 were superior in drought resistance to S. C. 12/4. The growth was so excellent in comparison with that of S. C. 12/4 that 10 acres of both upland and lowland fields have been planted for more extensive trials.

Mayaguez seedlings Nos. 3, 7, and 42, each occupying a $\frac{1}{20}$-acre plat, were planted at Coloso in November, 1929, in alternate 2-row series with B. H. 10/12 as the check. B. H. 10/12 had to be replanted on account of adverse soil conditions. All the Mayaguez seedlings germinated well and at 8½ months were superior to B. H. 10/12 by 4 to 6 inches in height and by three to four in number of shoots per stool. No mosaic was found in these three seedling varieties although the infection in the B. H. 10/12 plats averaged 16.2 per cent. The Mayaguez seedlings were cut for seed and will be grown more extensively for the 1932 grinding season.

Summary of Results of Cooperative Trials with Fourth and Fifth Year Seedlings

Observations on several thousand stools each of Mayaguez seedlings Nos. 3, 7, and 42 showed no traces of mosaic infection at Eureka, Hormigueros, and Coloso, although interplantings of B. H. 10/12 were heavily infected. These three varieties may not prove to be entirely immune to mosaic, but from a commercial point of view they may be so regarded. In growth these varieties compared well with B. H. 10/12 during the first 6 to 10 months at Fajardo, Aguirre, Hormigueros, Eureka, and Coloso. Mayaguez 28 is considered to be desirable for its prolific stooling habit at the Central Mercedita, Ponce. Mayaguez seedlings occupying a total of 72.5 acres of land are now being grown for the 1931 and 1932 grinding seasons. The superiority

FIGURE 13.—Progress in sugarcane breeding for disease resistance and large girth. Varieties Mayaguez seedlings Nos. 151, 42, and 7 are immune to mosaic and equal P. O. J. 2878 in cane girth. The canes of P. O. J. 2878 are shown larger than average for contrast

in cane girth of Mayaguez seedlings Nos. 151, 42, and 7 is shown in Figure 13. The very thin canes on the left are those of Uba and Java 36.

PLANTING IN BARRELS

In Barbados the planting of sugarcane in barrels has been found to induce arrowing in B. H. 10/12 and other late-flowering cane varieties. To determine the practicability of this method for Mayaguez, 100 barrels were filled with clay soil and planted with B. H. 10/12. Fifty of the barrels were placed on Las Mesas, where the elevation is 1,000 feet, and the others were placed at Mayaguez near sea level. Two ounces of a complete fertilizer were added to each barrel at time of planting and was followed two months later by a heavy mulch of grass. The barrels were watered once a week during the dry periods. The internodes were painted with tar to protect them from rats. The canes, when 14 months old, in December, had not developed arrows. They are to be allowed to grow for another year to determine whether they will blossom.

REPORT OF THE AGRICULTURIST

By H. C. Henricksen

CITRUS INVESTIGATIONS

ROOT DEVELOPMENT

Study of the development of the root systems of different citrus stocks in the nursery and of large citrus trees in the field is in progress. The entire root system in some instances, and only part of the system in others, was exposed, the earth being washed away from the roots with a stream of water under pressure.

CONTROL OF TIME OF BLOOMING

It is generally believed that the time of blooming of citrus trees can be controlled, at least to some extent, by the kind of fertilizer applied and the time of application. However, so many unknown factors are involved in this, the most important problem of the industry at present, that local growers can not expect to obtain uniform results by fertilizing. Experiments were started a year ago on different representative soil types to determine the length of time the various fertilizer salts required to move in the soil and the extent of their movement. The results obtained were unsatisfactory because of the failure to control the factor of moisture. An exceptionally scant rainfall during several months caused the fertilizer salts to dissolve and become distributed in the soil much more slowly than had been anticipated. This difficulty will be less of a problem in the future because irrigation water is now available in many of the groves. The work is being continued.

In connection with the fertilizer work, it was planned to analyze the various parts of certain citrus trees from time to time to determine the rate of absorption and metabolism of the various ions in the fertilizers used. The results to date are valuable mainly as a guide for future work.

ANALYTICAL METHODS

Some of the carbohydrates and proteins were found to change rapidly after the material for analysis was severed from the tree, except when the tissue was frozen immediately and kept frozen until wanted for use. The material was macerated in the field by means of a food chopper because suitable refrigeration was not available. Twenty grams of the macerated material was immediately dropped in boiling 85 per cent alcohol, together with a little powdered chalk. In the laboratory the tissue was extracted with 80 per cent alcohol by heating in a boiling water bath under a reflux condenser for two hours. After settling had taken place the alcohol was decanted off, and the process was repeated twice with fresh portions of alcohol. After the third extraction the residue was filtered off and washed with alcohol. The combined portions of alcohol used for extraction and for washing were made to volume, usually to 700 cubic centimeters. Half the solution was measured into a Kjeldahl distillation flask, and the nitrogen in the residue after the alcohol was distilled off was determined by the Kjeldahl-Gunning (*1*, *p. 6–8*) method.

The alcohol was distilled from the other half, and the residue was dissolved in hot water. The solution was cleared with neutral lead acetate and freed from the lead with monobasic sodium phosphate, after which the volume was made up to 200 cubic centimeters. Half the solution was placed in the cold with 2 cubic centimeters of toluol for 72 to 96 hours during which time the glucosides separated out by crystallization. The rest was used for determination of the sugars. The monosaccharides were determined by reduction of Fehling's solution, and titration with potassium permanganate, according to the method of Bertrand, as cited by Browne (*2, p. 426; Appendix Table 20*). The disaccharides were determined in a similar manner after inversion with invertase. The readily hydrolyzable polysaccharides were determined in the residue from the alcohol extraction. Hydrolysis with 1 per cent hydrochloric acid was accomplished by heating 300 cubic centimeters for three hours at 90° C. The total nitrogen was determined on a separate moisture-free sample in which the moisture and ash constituents were also determined.

SOME TYPICAL RESULTS WITH LEAVES

The moisture content of the leaves varied with that of the soil and the air, and with the species of tree, but principally with the vegetative condition of the leaves of any one tree. For instance, old, mature leaves from a normal grapefruit tree that was well supplied with moisture usually had a moisture content of about 60 per cent, whereas new, partly developed leaves, picked at the same time, usually contained about 70 per cent of moisture, and in exceptionally vigorous tissue it was 77 per cent. Neither nitrate nor ammonia nitrogen was found in any of the tissue examined. It was not ascertained at what point in the tree the inorganic nitrogen is metabolized. The total nitrogen varied from about 2 per cent in old, mature leaves, calculated on the moisture-free tissue, to 3.5 per cent in new, partly developed leaves. The amount of nitrogen extracted from the fresh tissue with 80 per cent alcohol usually was a fairly constant percentage of the total regardless of the stage of maturity of the leaves when they were picked from the same tree at the same time. For instance, in three sets of leaves from one tree, varying from very tender to old and mature, the alcohol-extractable fraction was 22 to 23.5 per cent of the total. In three sets of leaves from another tree it was 30 to 34 per cent of the total, which illustrates the large variation between one tree and another, and the small variation in the foliage from any one tree.

Pentoses were not found in appreciable quantities in the leaves of normal trees in the carbohydrate determinations. The monosaccharide-hexoses, chiefly glucose, varied with the vegetative condition, being always considerably higher in young, very tender growth than in old, mature tissue. The disaccharides varied chiefly with the time of day the leaves were picked. The polysaccharides varied partly with the stage of maturity of the tissue, and partly with the time of day it was picked. Expressed in percentage of moisture-free tissue, the monosaccharides were 8.3 for new, partly developed leaves; 7.6 for new, fully developed leaves; and 2.82 for old, mature leaves. The disaccharides were 4.52 for new, partly developed leaves: 3.8 for new, fully developed leaves; and 4.7 for

old, mature leaves; and the polysaccharides were 7.86 for new, partly developed leaves; 7.5 for new, fully developed leaves; and 6.95 for old, mature leaves.

The glucosides varied with the species of tree and with the vegetative vigor. The content in the leaves of any tree was governed by the stage of maturity of the tissue. The glucosides separating by crystallization after 72 hours or more were filtered, dried at 80° C., and weighed. The glucoside content, calculated on the moisture-free tissue, varied from 2.5 to 3.5 per cent for young, tender grapefruit leaves, and from 0.25 to 0.35 per cent for old, mature leaves from the same tree. In young leaves from rough-lemon trees, the glucoside content was much less than in leaves of corresponding maturity from grapefruit trees, and in leaves from orange trees the content was less than in those from rough-lemon trees.

Enzymes were determined with the following results: Oxidase was not found. Peroxidase was present in abundance in both the mature and the immature foliage. Reductase and tyrosinase were not found. The catalase content generally varied with the vegetative vigor of the tree. Except for this variation the catalase content was governed by the stage of maturity of the leaves. The very immature leaves of any one tree contained much less catalase than nearly or fully mature leaves. The diastase content was plentiful in leaves of normal trees, being higher in the partly mature tissue than in the very young or very old tissue. Invertase was present in all the leaf tissues examined, being higher in young, vigorous leaves than in old, dormant leaves.

PINEAPPLE INVESTIGATIONS

Pineapple investigations, begun several years ago to determine the most desirable slips and suckers for planting, were completed. The results have been published for general distribution.[8]

SHIPPING PLANT-RIPENED FRUIT

In addition to having previously solved certain shipping problems, the station during the year gave demonstrations in refrigeration on steamers and in precooling on the wharf for the purpose of convincing shippers and receivers that plant-ripened fruit will withstand shipment and that fruit can profitably be shipped in a much more advanced stage of maturity than has hitherto been supposed. Several crates of packed fruit in different stages of maturity were kept under a temperature of 40° F. for one or two weeks. After the fruit was removed from refrigeration it was kept under observation in San Juan, or was shipped to New York and reported upon from there. The results were similar to those previously obtained: Green fruit assumed the usual yellow color after it had been kept under a temperature of 40° for one or two weeks, and plant-ripened fruit under corresponding treatment showed very little change.

CONTROL OF TIME OF BLOOMING

The pineapple plant can be induced to bloom by applying smoke to it. This fact has been taken advantage of by several growers

[8] In a mimeographed number of Agricultural Notes, available copies of which may be had upon application to the director of the station.

who have from time to time covered part of their pineapple fields with a cheap grade of muslin and subjected the covered plants to smoke produced by wood fires topped with moist leaves and soil. Such treatment for one night usually causes the plants to bloom, regardless of their age or size. Therefore only large plants that are capable of producing marketable fruit should be induced to bloom. The bloom usually appears six weeks after smoking has been done. The writer has attempted to simplify and standardize the method now in use. The results to date are not conclusive, but indicate that valuable information may be secured by continuing the investigation.

FRUIT GROWERS' ORGANIZATION

From 35 to 75 fruit growers attended the meetings held in their interest. The agriculturist acted as secretary of the meetings and prepared a report on each for distribution among the growers. Two field meetings were held during the year under the leadership of the agriculturist. All questions submitted to the agriculturist, either by mail or in person, were answered. Notwithstanding the fact that the agriculturist was not able to devote much time to extension work, he occasionally visited all the fruit-growing districts between Rio Piedras and Arecibo, and in the Cidras Valley. He also made two visits to Mayaguez for the purpose of assisting fruit growers there.

REPORT OF THE PARASITOLOGIST

By H. L. Van Volkenberg

GENERAL SURVEY

Parasites of cattle have received the most attention at the station because cattle constitute the most important branch of the livestock industry in Porto Rico.

Data secured from autopsies, abattoir observations, and fecal examinations show that the stomach worm is the most common and widespread of the internal parasites, closely followed by the nodular worm.

The nodular worm is of great importance for the reasons that it causes numerous losses, an effective curative treatment for it is not known, and older animals do not acquire the resistance to it that they do to the stomach worm. Persistent diarrhea in old and weak animals is often found associated with the nodular worm.

The lungworm and the hookworm are not widely distributed as compared with the other two species, but are serious pests on certain farms and in restricted localities. Coccidia are very frequently found in fecal examinations, but only in a few instances has coccidiosis been observed.

The cattle tick and the liver fluke attack cattle of all ages. Both parasites can be eradicated. Apparently only one species of snail in Porto Rico is the intermediate host of the liver fluke. By destroying this snail the liver fluke can be controlled.

The native goat is attacked by a great variety of troublesome external and internal parasites. For this reason goats are successfully raised in flocks only in the more favorable dry regions. The goat may serve as a source of infection for stomach worms in cattle. The

improvement of the native goat by importation of improved breeds can not be successful until the owners learn to control the parasites affecting the animal.

The most serious parasites of swine are lungworms and the swine kidney worm. The thorny-headed worm and the swine hookworm (*Crassisoma* sp.) are common, but apparently are not important. This hookworm is not a persistent bloodsucker. Specimens engorged with blood have not been found. For some unknown reason the ascarid is not common. It probably will never be necessary to adopt a swine-sanitation system in Porto Rico. Pigs have been and are being raised successfully in permanent pens over a period of years.

Of the important internal parasites of poultry, capillarids have been most frequently found, followed by species of the genera Heterakis and Ascaridia. The tapeworm has been found less frequently than the ascarids. Coccidia are encountered in over a third of the fecal examinations. Indirectly the cockroach causes many deaths annually. The cockroach that has been poisoned by phosphorus paste may be eaten by poultry. One cockroach may ingest a sufficient amount of the poison to kill an adult bird.

TICK FEVER (PIROPLASMOSIS)

Apparently there are two or more types of the tick fever in Porto Rico, as is indicated by the size and the shape of the parasite in the blood. The more common type of parasite found in Mayaguez and vicinity corresponds to *Piroplasma argentinum* occurring in South America. This parasite is not as large as *P. bigeminum*, is usually found singly in a red blood corpuscle, and does not often appear as pear shaped. The disease caused by this parasite responds to treatment with quinine, especially if administered early in the attack. Injecting quinine hydrochloride intravenously in doses of 5 grams daily per adult animal will hasten the action of the remedy.

TAPEWORM OF CATTLE

An attempt was made to find the intermediate host of *Moniezia expansa*, the common tapeworm of cattle in Porto Rico. The specific identity of this tapeworm was determined by the zoological division of the Bureau of Animal Industry, United States Department of Agriculture. The parasite is found in both goats and cattle. The native goat, however, apparently is not a natural host, since completely developed oncospheres frequently are not found in the ova of worms from this animal. At the local abattoir tapeworms can be easily detected in the freshly washed intestines of cattle and recovered therefrom. The tapeworm is more common in young cattle, although adults are often infested. Usually adult cattle do not harbor more than one or two tapeworms. The worms are often found in masses in goats. The tapeworm is most numerous during the wet season and is found more frequently in some districts than in others. Unsuccessful attempts were made to infest several kinds of insects, including flies, ants, sowbugs, dung beetles, and water beetles, by feeding cestode material. From specimens collected in the field two species of beetles were found to be infested with the intermediate stage of a tapeworm. The dung beetle *Ataenius stercorator* was found with a cysticercoid. The water beetle *Tropisternus collaris* also harbors a cysticercoid, probably the tapeworm of a water-feeding

bird. This water beetle is also infested with the embryo of a thorny-headed worm. It is possible to infest both pigs and calves with this thorny-headed worm by feeding the beetle, but the worm does not develop in the calf. The specific identity of the beetles was determined by Dr. Stuart Danforth, of the College of Agriculture at Mayaguez.

FORAGE CROPS FOR PORTO RICO

By D. W. May

A forage crop is one that serves as a feed whether green or cured, and may be fed either in the pasture or in the manger. It may be grazed, fed whole, or cut. Forage of some kind can be produced on all the soils of Porto Rico except in those containing large amounts of salts or sand or in regions where the rainfall is scant. Production in these regions is limited to the saltbushes on the salty types, and to the cacti where moisture is exceedingly low. The alkali lands are not extensive, and are excellent for sugarcane growing where the salts can be and are removed, or the harmful effects counteracted. The station has grown saltbushes on alkali land in the hope that they would adsorb the salts and also provide forage for livestock. The amount of salts extracted was so small and the forage obtained of such slight value as to render such plantings of doubtful value in furthering either objective. Drainage is recommended for the elimination of salts from alkali land.

The areas on the island in which the rainfall is so light as to preclude the production of some kind of forage are small. The station introduced the spineless cactus into Porto Rico and also found it growing near Lares. The plant grows slowly, however, and for this reason can not be recommended as an economic feed.

Certain of the grasses and legumes that do well under favorable soil and climatic conditions are not always the best forage plants for the region in which they are grown. Trial plantings of various grasses and legumes should be made to disclose those which are best from an economic standpoint, and the latter should be planted.

GRAZING GRASSES

Of the various low-growing wild grasses on the island, the grama grass (*Stenotaphrum secundatum*) is the best known. Bermuda grass is now found growing in most regions in which sandy soils predominate. Java grass (fig. 3) grows readily from roots and makes a thick mat of both leaves and roots, and seeds profusely. It is hardy, better adapted to lawns than any of the other grasses tested, and crowds out the native grasses. Java grass turns brown under conditions of prolonged drought, but does not die out. The leaves have a remarkable water-holding capacity and drops of rain or dew remain in their folds for some time after the sun strikes them. This fact undoubtedly helps to keep the grass green after other varieties have dried. Java grass is considered to be of value for upland pastures and hillsides, and is readily grazed by cattle. These grasses, while yielding considerable nutriment as grazed, usually can be replaced by others equally nutritious which give larger yields and at the same time fit into a scheme of more rapid soil improvement.

The two grasses most commonly planted in the island are Para grass, or malojillo (*Panicum barbinode*), and guinea grass (*P. maxi-*

mum). These grasses are both pastured and harvested. Malojillo is better adapted to the low, wet lands than is guinea grass, and will thrive in many types of soils and under various conditions. It makes very persistent growth and sometimes becomes a pest in cane fields, growing vigorously and sending down roots from the joints. Two varieties of malojillo are found growing in Porto Rico. Guinea grass does not send out runners, is upright, prefers a limestone soil, and requires less moisture than does malojillo grass. Where the soil and climatic conditions are better for one, it will drive out the other. These grasses are very popular with local stockmen, and a new introduction will have to be very good to supplant them.

CUT GRASSES

Of the various forage grasses introduced by the station, Guatemala grass (*Tripsacum laxum*) (fig. 2) is the most promising at this time. It gives enormous yields, ratoons well, and is very palatable to livestock. Guatemala grass remains green and grows fairly well even in dry weather. Napier, or elephant grass (*Pennisetum purpureum*) (fig. 1) is a close second. It also ratoons well. A cutting made the year the crop was planted yielded 19⅓ tons per acre, and another cutting, made in the fourth year, gave 12.8 tons. The grass should be cut frequently, as it soon becomes hard, which greatly increases the percentage of waste in feeding.

Natal (*Tricholaena rosea*), a South African grass, has been tried in various localities and found very promising, especially on sandy soils. It not only grows readily when sown in cultivated fields, but under certain conditions spreads voluntarily to uncultivated land. Like many other introduced grasses, Natal grass is not well suited for pasturing, although it is short in growth and covers the ground well. Indications are that it is of value chiefly for use as hay or silage, and for soiling. Natal grass is propagated by seed. Time of planting may vary with the locality. Before the grass is planted the soil should be well pulverized, and all weed growth should be killed. The seed may be sown broadcast on fairly clean land and further cultivation will not be needed. On the heavier soils, and especially in districts of plentiful rainfall, Natal grass will not yield as heavily as elephant grass, but on the lighter soils and in districts that suffer from occasional drought Natal grass is the most profitable grass grown at present.

Sugarcane in all stages of its growth is a splendid feed for livestock. Often when the price of sugar is low a greater profit can be made by feeding the cane to cattle than by using it for sugar making. Uba cane will give greater yields of forage on high lands than will the better sugar-producing canes. (Figs. 4 and 14.)

The average yield per acre of green forage for five grasses, grown on similar soils at the station and cut at the beginning of the dry season as they were approaching maturity, was as follows: Uba cane, 54.7 tons; Guatemala grass, 35.4 tons; elephant (Napier) grass, 32.6 tons; guinea grass, 17.4 tons; and malojillo (Para), 19.6 tons. The grasses were cut and fed whole, fed from racks above mangers, and cut in half-inch lengths and fed from troughs. (Fig. 15.) The losses or uneaten percentages were as follows: Uba cane, 27.5 per cent whole, 13 per cent cut; Guatemala grass, 21 per cent whole, 18.5 per cent cut; elephant grass, 55 per cent whole, 50 per cent cut; guinea

FIGURE 14.—Kavangire, a Japanese cane; immune to mosaic disease

FIGURE 15.—Feeding rack for fresh-cut grass

grass, 27 per cent whole, 37 per cent cut; malojillo, 30 per cent whole, 26 per cent cut. Estimated on the percentages consumed, the grasses yielded per acre as follows: Uba cane, 39.6 tons when fed whole and 47.6 tons fed cut; Guatemala grass, 28 tons fed whole and 28.9 tons fed cut; elephant grass, 14.7 tons fed whole and 16.3 tons fed cut; guinea grass, 12.7 tons fed whole and 11 tons fed cut; and malojillo, 13.7 tons fed whole and 14.5 tons fed cut. These yields are relative and would not be obtained from all lands or during all seasons. The grasses ratoon well, and annual yields depend on such factors as soil, rainfall, and the stage and frequency of cutting. Each planter may find the growing of two or more of the grasses more profitable than the growing of one, as his soils vary. All the grasses are worthy of trial.

FIGURE 16.—Trough for feeding cut grass

The percentage of loss in feeding is least with the cut Uba cane. This plant is so sweet that the animals readily eat nearly all the stalk. The next lowest loss is with the Guatemala grass for the same reason. The woody stem of guinea grass is discarded, and the animals separate the stalk and leaves best after the grass has been cut into short pieces. When the whole grass is fed the animals must consume the stems to get the leaves. For this reason a smaller percentage of the grass is consumed when it is fed cut than when it is fed whole. When the larger grasses are cut the animals eat all but the woody stems. The heavy losses in feeding elephant grass are due to its woody stems. Elephant, guinea, and malojillo grasses should be fed when they are young and succulent. It has not been found profitable to run these grasses through the cutting box.

At the station, grass for forage is run through a cutter set on a concrete floor. Thence the grass is pushed to an adjoining trough which is built on a lower level. (Fig. 16.) The trough is separated

from the side on which the grass is cut by a woven-wire fence under which the grass is pushed to the animals feeding on the opposite side.

The sorghums, kafir corn, milo maize, and allied crops do well and are less troubled by insects than is maize. They mature in three to four months and yield considerable grain as well as fodder. At the station they yielded an average of 11 tons of green matter per acre. These crops are recommended for regions where the rainfall varies from 20 to 30 inches per annum and is precipitated during three or four consecutive months.

The millets produce well under similar conditions. Pearl millet made excellent growth at the station, yielding over 14 tons of forage per acre.

Molasses grass (*Melinis minutiflora*) (fig. 3) propagates from rootstocks and has a heavier leaf development than malojillo. It is the most productive grass grown in the lowlands. It is much relished by livestock and is a very valuable introduction. The fine hairs with which this grass is covered, and the sticky exudation, hinder the seed tick from climbing upon the plant and so act as deterrents to the spread of the cattle tick. This grass is called "Yaragua" in Porto Rico.

Paspalum grass withstands long drought. It requires cultivation during the rainy season, else it will be overgrown by the native grasses.

Sudan grass does best in the drier regions. During rainy weather it is attacked by fungus. Sudan is a bunch grass and grows readily from seed.

Rhodes grass grows well, but shows no outstanding merit under trials at the station.

Johnson grass has been introduced into the island, but not by the station. While it grows well, it is likely to become a pest because it propagates rapidly by rootstocks.

Bluegrass will flourish for a time, but will not make a sod or produce seed.

LEGUMES

Legumes should be grown for forage wherever they will grow, because, in addition to yielding feed, they add nitrogen to the soil and thus improve its fertility.

Results of experiments at the station show that to date the velvetbean is the best legume for forage. (Fig. 17.) Introduced as an ornamental, the velvetbean was found to yield a forage in the rank vines and a concentrated feed in the beans. Otherwise waste places should be devoted to the velvetbean, the yield of which will be found to increase with each succeeding crop.

The velvetbean may be planted at any time in the Tropics, and may be continuously cropped. The station has obtained yields of 9 tons in three months to 16 tons in eight months. Velvetbeans are excellent for planting with cane in the stubble remaining after each cutting when the land is to be thrown out of cultivation, and likewise on worn pineapple lands. (Fig. 18.) They will enrich the soil for succeeding crops. The velvetbean requires a minimum of cultivation. The plant grows rapidly and after starting will hold its own, climbing over and smothering weeds and grasses. No insect or fungus pests seriously attack the crop in Porto Rico.

The vines of the velvetbean are best fed in racks. Running the vines through a cutter will not pay. The beans are best fed in the pod, as hulling is difficult and costly.

The seeds of the velvetbean retain their viability for a long time, probably because of their hard seed coat and their oil content. From

FIGURE 17.—Velvetbeans growing over corn

10 to 20 pounds of seeds are required to plant an acre. For seed production the velvetbean should be planted in time to ripen in the dry season, and it should be provided with a support to hold the pods off the ground and thus promote proper maturing. Corn and sunflowers can be used for this purpose. The velvetbean requires from five to eight months to mature.

The cowpea is an excellent forage crop and has the added advantage of providing food for man. It may be grown throughout the year, but spring and summer plantings do best. There are two general classes of cowpeas—the bunch and the runner, the latter mak-

FIGURE 18.—Velvetbeans growing over sugarcane

ing vines 5 to 6 feet long. The earliest maturing kinds ripen in 70 days. Yields of 30 bushels per acre have been obtained at the station. The cowpea is occasionally somewhat damaged by a leaf hopper. (Fig. 19.)

Varieties of cowpeas differ both in yields and in flavor. When a certain variety has been found to be adapted to a locality its use should be continued.

Soybeans will grow better than cowpeas under certain adverse conditions and are less subject to insect attack. At the station they usually produced more seed but less vine than did the cowpea. Two things are necessary to make the soybean a success—the development of varieties that are adapted to the soil and the climate and the development of methods for better utilization of the crop. In Porto Rico the soybean matures sooner but makes less leaf and stem growth in winter than in summer. Pods form in 6 weeks and mature in 12 weeks in winter.

FIGURE 19.—Cowpeas as a cover crop for coconuts

MISCELLANEOUS FORAGE CROPS

Less important forage crops have been tried at the station but are rated much lower than those already discussed.

The pea grows rankly, some varieties exceeding 5 feet in height. (Fig. 20.) After the peas have been picked the vines will provide good forage for cattle.

The beggarweed makes fair growth on sandy soils. The second and third crops on the same land are better than the first crop. Beggarweed is subject to damage by leaf hoppers.

Lupines and vetches fail to make satisfactory growth. Sunflower grows well and yields considerable forage and seed. The seed is especially good for poultry.

Rape gives fair yields. It is not recommended as a feed except for pigs.

Clovers and allied plants tried at the station include alsike, berseem, crimson, red, Lespedeza, genge, white, sapling, mammoth tre-

foil, bur, peavine, subterranean clover, and sweetclover. These legumes were inoculated with the proper nitrogen-fixing bacteria in every instance, planted in a well-prepared seed bed, and cultivated for several months. All failed to grow satisfactorily compared with the progress of the same kind of plants in the Temperate Zone. Moreover, they appeared to be unadapted to the Tropics. They did not produce viable seed or persist after the first year. Cultivation was necessary in all cases to keep them from being overcome by weeds and grasses.

Alfalfa has been tried many times at the station and in various other parts of the island. On high lands it is a failure. On alluvial lands it grows well for a few months but does not persist. In rainy seasons it is overcome by rank-growing grasses. The crop gave best results on alluvial land that was limed at the rate of 1,500 pounds per acre. The yield in three months from time of seeding was at

FIGURE 20.—Garden variety of peas over 5 feet in height

the rate of 4 tons per acre of green matter. When the land was again limed at the rate of 1,200 pounds, the yield at the second cutting, three months later, was at the rate of 6 tons per acre. The alfalfa was smothered by grasses during the rainy season following.

The residues of a number of plants that are grown for food are of value as stock feed. The largest residue comes from sugarcane, the tops of which are fed whole or cut. Molasses from cane is often low enough in price to permit its use as a feed. Best results are to be had from diluting the molasses and sprinkling it over the grass fed. Molasses is very nutritious and when fed with grass causes the animals to consume more and waste less of the latter than is the case when the grass is fed alone.

The root crops commonly grown for human food are the yautia, the yuca or cassava, and the sweetpotato. Yields of more than 15 tons of the latter have been obtained at the station. When the price justifies it, they may be fed to animals with advantage.

Pea vines (garden variety) and the foliage of the gandul or pigeon pea make good forage.

The pods of the algaroba (*Prosopis juliflora*), introduced from Hawaii, make excellent feed, while the tree, a legume, is good for pastures. The foliage is protected from stock by thorns. The station has distributed thousands of seedlings of the algaroba. A great many will be found on the south side of the island in the pastures. The tree is best adapted to the high and dry lands, but will grow in all parts of the island. Planted closely and given frequent trimming, it makes a very beautiful hedge. The algaroba improves the soil on which it grows. The flower is a source of excellent honey, and the pod is filled with a sweetish pulp and is greatly relished by livestock. The wood makes excellent fuel and is also valuable for many building purposes. The tree differs entirely from the algarrobo (*Hymenaea courbaril*) of Porto Rico.

SILAGE

Ensiling fodders is a common practice where cold weather prevails in winter. It may be advisable for use in the Tropics when periods during which there is a surplus of forage are followed by periods of scarcity, due to drought. Silage is less palatable to livestock than is freshly cut forage, and has the added cost of storage and rehandling. Ensiling, however, can be done as successfully in the Tropics as in the Temperate Zone.

Corn, cane, malojillo (*Panicum barbinode*), elephant grass (*Pennisetum purpureum*), Guatemala grass (*Tripsacum laxum*), velvetbeans, and cane tops have been ensiled at the station. Corn made the best silage, comparing in flavor and palatability with that made in the Temperate Zone. Cane came next, but gave trouble during the fermentation process. Its high sugar content is conducive to the production of alcohols and acids, and the processes are difficult to halt. Even with cane tops, fermentation passed from the alcoholic to the acetic stage when there was too much moisture, and it did not take place at all when the tops were too dry. The grasses and velvetbeans made poor silage, due largely to the fact that they are too light to pack well unless heavily weighted. The grasses lacked sufficient juice to ferment well, and the resulting product was dry and developed a musty odor. The velvetbeans were juicy enough, but they were either not of the proper composition or of the proper quality for silage making, and the resulting product was black and unsavory.

Cattle differ markedly in their liking for silage, some taking readily to it and others scarcely at all. It is probably eaten more readily in the Temperate Zone because it is usually fed in winter when green fodders are not available. Silage is of doubtful value at the station, where the annual rainfall is fairly well distributed and green forage usually is available throughout the year. Even when it was well made, the station animals ate it with reluctance, wasting 75 per cent of the grasses and 55 per cent of the sugarcane. Results of experiments show apparently no difference between silage made in the Tropics and that made in the Temperate Zone. Corn silage has been carried over at the station for two years with good results.

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